THE DOE RUN COMPANY

SUITE 300
1801 PARK 270 DRIVE
ST. LOUIS, MO 63146

Michael Montgomery
Attorney
Ph. 314- 453-7678
Fax: 314-453-7626
mmontgomery@doerun.com

October 30, 2012

CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Chief, Env. Enforcement Section
Environment & Natural Resources Div.
U.S. Department of Justice
P.O. Box 7611 Ben Franklin Station
Washington, D.C. 20044-7611
Re: DOJ No. 90-5-2-1-0370/1

Chief, Waste Enforcement and Materials
Management Branch
Air and Waste Management Division
U.S. Environmental Protection Agency
Region 7
11201 Renner Blvd.
Lenexa, KS 66219

Office of Regional Counsel
U.S. Environmental Protection Agency
Region 7
11201 Renner Blvd.
Lenexa, KS 66219

Director
Division of Environmental Quality
Missouri Dept. of Natural Resources
1101 Riverside Drive
Jefferson City, MO 65102

Re: The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 176 – Semi-Annual Report

Dear Agencies:

Pursuant to Paragraph 176 of the Consent Decree, Doe Run submits this Semi-Annual Report. Exhibits to the Semi-Annual Report are contained on the enclosed disk. Progress reports required pursuant to Paragraphs 43 and 47 are provided as exhibits to the Semi-Annual Report. As noted in the Semi-Annual Report Doe Run has modified the previously submitted SWMPs and UWMPs. The modified plans are attached. A Certification consistent with Paragraph 181 is provided with this Semi-Annual Report, which serves to certify the Semi-Annual Report and exhibits thereto. The original Certification is attached to the Semi-Annual Report being submitted to EPA Region 7. All other recipients will receive a copy of the Certification on the enclosed disk.

Should you have any questions regarding this matter, please feel free to contact me.

Sincerely,

Michael Montgomery

cc: Steven Sanders, EPA Region 7 (via email Sanders.Steven@epa.gov)
Donald Toensing, EPA Region 7 (via email Toensing.Donald@epa.gov)
Leanne Tippett-Mosby, MDNR (via email Leanne.tippett.mosby@dnr.mo.gov)
Missy Seeligman, MDNR (via email missy.seeligman@dnr.mo.gov)
Betsy Crawford, MDNR (via email betsy.crawford@dnr.mo.gov)
Stacy Stotts, Stinson, Morrison, Hecker LLP (via email sstotts@stinson.com)
Louis Marucheau, Doe Run (via email lmarucheau@doerun.com)
Aaron Miller, Doe Run (via amiller@doerun.com)
Michael Montgomery, Doe Run (via email mmontgomery@doerun.com)
Matt Wohl, Doe Run (via email mwohl@doerun.com)
Mark Cummings, Doe Run (via email mcummings@doerun.com)
Steve Batts, Doe Run (via email sbatts@doerun.com)
Steve Arnold, Doe Run (via email sarnold@doerun.com)
Jim Lanzafame, Doe Run (via email jlanzafame@doerun.com)
Gary Hughes, Doe Run (via email ghughes@doerun.com)
C. Rusty Keller, Doe Run (via email rkeller@doerun.com)
Greg Sutton, Doe Run (via email gsutton@doerun.com)
Benjamin Walczak, Doe Run (via email bwalczak@doerun.com)

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 176 – Semi-Annual Compliance Report
October 31, 2012

Pursuant to Paragraph 176 of the Consent Decree between the United States and the State of Missouri and The Doe Run Resources Corporation d/b/a The Doe Run Company and the Buick Resource Recycling Facility (collectively "Doe Run"), Doe Run hereby submits this Semi-Annual Compliance Report.

This Semi-Annual Report provides the information required by Subsections a. through i. of Paragraph 176 of the Consent Decree, as well as specific reporting requirements of Paragraphs 43 and 47. For ease of reference, the paragraph requiring the specific information or implementation is included with each response.[1] Doe Run acknowledges that it is subject to and required to comply with all obligations within the Consent Decree, including those that do not have a specific implementation obligations. The certification provided applies to the information provided in this report and exhibits.

Pursuant to Paragraph 176, Doe Run has stated in the previous Semi-Annual Report that certain obligations have been completed. Doe Run has no additional information to report regarding those obligations beyond that reported in the previous Semi-Annual Report submission. Please see the previous Semi-Annual Report submission for details.

Paragraph 176a. – A progress report on the implementation of Sections V-X, XIV and XV.

V. COMPLIANCE REQUIREMENTS: CLEAN AIR ACT

14. Doe Run is currently on schedule to cease operations described in Paragraph 14 and in accordance with the schedule set forth therein.

15. This paragraph is not yet applicable. Therefore, there is nothing to report at this time.

19. Monthly logs that track refined lead metal produced on a daily basis, using the spreadsheet attached as Exhibit A to the Consent Decree. This information is contained in Column AA, "Fin Gds Cast," of the spreadsheets attached as Exhibit A.[2] Except as required by Paragraph 176g, the obligations in this Paragraph have been implemented and will not be addressed in future status reports.

20. In accordance with subpart (a) Doe Run tracks sinter throughput and blast furnace sinter throughput on a daily basis. Logs providing this information are attached

[1] Those paragraphs that contain neither specific implementation requirements related to injunctive relief nor specific reporting requirements have not been listed in this Semi-Annual report.
[2] The data provided in Exhibits A, B and AA is extracted from Doe Run accounting software and, therefore, reflects a partial day offset between calendar day and accounting day.

as Exhibit A. Daily sinter throughput is contained in Column J, "Sinter Made" and blast furnace sinter throughput is contained in Column T, "Sinter Use, Total," of the spreadsheet attached as Exhibit A. In accordance with subpart (a)(i), a 12-month rolling tonnages of Sinter Production are illustrated in the "Herculaneum Production – Consent Decree Compliance Reports" attached hereto as Exhibit B. In accordance with subpart (a)(ii), 12-month rolling tonnages of Blast Furnace Sinter Consumption are illustrated in the "Herculaneum Production – Consent Decree Compliance Reports" attached hereto as Exhibit B.

In accordance with subpart (c)(i), Column K, "SO2 (K) Lbs," of the spreadsheet attached as Exhibit A illustrates the SO_2 Short-term Limit. In accordance with subpart (c)(ii), the tonnages associated with the SO_2 Mass Cap are illustrated in the "Herculaneum Production – Consent Decree Compliance Reports" attached hereto as Exhibit B.

In accordance with subpart (d), Doe Run maintains and operates a CERMS on the main stack of the Herculaneum Lead Smelter Facility, which is capable of measuring the hourly mass rate of SO_2 emissions. The CERMS has been continuously operated except during breakdowns, repairs, calibrations checks and zero-span adjustments. When the CERMS is down, Doe Run uses substitute data as provided in subparagraph (iv). The prior Semi-Annual Report stated that on March 20, 2012[3], the entire facility lost power for an extended period, which resulted in a delay of some testing required. Testing was rescheduled once power was restored and the CERMS was repaired. Testing was conducted on May 18, 2012. Except as required by Paragraph 176d through 176i, the obligations in this Paragraph have been implemented and will not be addressed in future status reports.

VI. COMPLIANCE REQUIREMENTS: CLEAN WATER ACT

42. Doe Run submitted the Site-Specific Underground Water Management Plan ("Site-Specific UWMP") for the Fletcher Mine/West Fork Mine via letter dated April 4, 2012. There are no outstanding Site-Specific UWMPs submissions required. This obligation has been completed and will not be addressed in future status reports.

43. Reports describing implementation of the Site-Specific UWMP for the Sweetwater Mine, the Viburnum Mine, the Viburnum Mine #35(Casteel), the Buick Mine, the Brushy Creek Mine, and the Fletcher Mine/West Fork Mine are attached hereto as Exhibit C through Exhibit H.

44. Doe Run has modified the following Site-Specific UWMPs based on new information and data gained through implementation of the Site-Specific UWMPs: the Sweetwater Mine UWMP, the Viburnum Mine UWMP, the Viburnum Mine #35(Casteel) UWMP, the Buick Mine UWMP, the Brushy Creek Mine UWMP, and the Fletcher Mine/West Fork Mine UWMP. The modifications include: 1) revisions to the sampling schedule; 2) transition to a calendar quarter schedule for inspections; 3) revisions to the

[3] The facility was without power from March 20, 2012 through the end of the relevant reporting time frame for the prior Semi-Annual Report and was restored on April 28, 2012.

Record Keeping and Best Management Practices; and 4) grammatical and other minor corrections to individual Site-Specific UWMPs. The Site-Specific UWMP for the Sweetwater Mine has also been modified to address the work to reduce the flow at CDH7. The modified UWMPs are attached hereto as Exhibit I through Exhibit N.

46. In accordance with subpart (b), Doe Run submitted the Site-Specific Surface Water Management Plan ("Site-Specific SWMP) for the Herculaneum Lead Smelter Facility via letter dated January 10, 2012. In response to comments and a partial disapproval from EPA and MDNR which was received by Doe Run on February 24, 2012, Doe Run submitted a revised Site-Specific SWMP for the Herculaneum Lead Smelter Facility on March 26, 2012. EPA and MDNR have not responded to the revised submittal during the relevant timeframe for this Semi-Annual Report. Doe Run submitted a Site-Specific SWMP for the Glover Facility via letter dated March 1, 2012. The Site-Specific SWMP for the Glover Facility was approved on April 16, 2012. Doe Run submitted a Site-Specific SWMP for the Buick Resource Recycling Facility via letter dated April 2, 2012. Doe Run received comments and a partial disapproval from EPA and MDNR on June 14, 2012. Doe Run submitted a revised Site-Specific SWMP for the Buick Resource Recycling Facility on July 16, 2012. EPA and MDNR have not responded to the revised submittal during the relevant timeframe for this Semi-Annual Report. Doe Run submitted a Site-Specific SWMP for the Viburnum Mine/Mill #35(Casteel) via letter dated April 30, 2012. The Site-Specific SWMP for the Viburnum Mine/Mill #35(Casteel) was approved by the EPA on June 14, 2012. Doe Run submitted the Site-Specific SWMP for the Brushy Creek Mine/Mill via letter dated May 30, 2012. The Site-Specific SWMP for the Brushy Creek Mine/Mill was approved by the EPA on July 15, 2012. Doe Run submitted the Site-Specific SWMP for the Buick Mine/Mill via letter dated June, 29, 2012. The Site-Specific SWMP for the Buick Mine/Mill was approved by the EPA on August 9, 2012. Doe Run submitted the Site-Specific SWMP for the Fletcher Mine/Mill via letter dated July 30, 2012. The Site-Specific SWMP for the Fletcher Mine/Mill was approved by the EPA on September 13, 2012. Doe Run submitted the Site-Specific SWMP for the West Fork Mine/Mill via letter dated August 27, 2012. The Site-Specific SWMP for the West Fork Mine/Mill was approved by the EPA on September 27, 2012. Doe Run submitted the Site-Specific SWMP for the Viburnum Mine/Mill via letter dated September 27, 2012. The Site-Specific SWMP for the Viburnum Mine/Mill was not approved by the EPA and MDNR during the relevant timeframe for this Semi-Annual Report. The remaining Site-Specific SWMPs submissions were not required to be submitted during the relevant time frame and information will be provided in future status report(s).

47. Reports describing the implementation of the Site-Specific SWMP for the Viburnum Mine/Mill #35(Casteel), the Brushy Creek Mine/Mill, the Buick Mine/Mill, the Fletcher Mine/Mill, West Fork Mine/Mill, the Herculaneum Lead Smelter Facility, the Glover Facility and the Buick Resource Recycling Facility are attached hereto as Exhibit O through Exhibit V.

48. Doe Run has modified the following Site-Specific SWMP based on new information and data gained through implementation of the SWMP: the Viburnum

Mine/Mill #35(Casteel), the Brushy Creek Mine/Mill, the Buick Mine/Mill, and the Herculaneum Lead Smelter Facility. All of the listed Site-Specific SWMPs were modified for grammatical corrections. The Site-Specific SWMP for the Herculaneum Lead Smelter Facility was also modified under the Best Management Practices section to modify the inspection schedule and under the Evaluation of the Effectiveness of Implemented Controls (Monitoring) section to remove the stormwater sampling requirement. The modified Site-Specific UWMPs are attached hereto as Exhibit W through Exhibit Z.

52. Doe Run submitted its Slag Storage Area Water Management Plan ("SSAWMP") to EPA and MDNR via letter dated January 31, 2011. The SSAWMP was disapproved by EPA and MDNR on April 28, 2011. A revised SSAWMP was submitted to EPA and MDNR on June 30, 2011. The revised SSAWMP has not been approved by the EPA and MDNR during the relevant timeframe for this Semi-Annual Report.

53. Implementation of the SSAWMP will begin upon approval by the agencies.

VII. CLEAN WATER ACT PERMITS: RESOLUTION OF MISSOURI STATE OPERATING PERMIT APPEALS AND COMPLIANCE DEADLINES

Doe Run expressly reserves its rights to submit to EPA requests for site-specific permit limits and/or submit requests to the Special Master, pursuant to Paragraphs 73(c), 77, 78, 79(a)(ii), 80, 81(d) and (g), and 82(a), (b) and (d), and Tables 4 and 6 of Appendix D of the Consent Decree.

83-87. Doe Run has not submitted a request for site-specific or permit-specific Whole Effluent Toxicity ("WET") limitations. Therefore, no response is required at this time. Doe Run expressly reserves its right to submit a request for site-specific or permit-specific WET limitations.

102. Doe Run has submitted Discharge Monitoring Reports to MDNR documenting its compliance with interim, final and/or alternate effluent limitations.

103. Doe Run submitted to EPA and MDNR a request for an Alternative Limit for Cadmium at the Sweetwater Mine/Mill via a letter dated January 11, 2012. In a letter dated February 24, 2012, EPA and MDNR deferred final action on Doe Run's request. Doe Run submitted to EPA and MDNR an updated request for an Alternative Limit via a letter dated May 16, 2012. In a letter dated August 9, 2012, EPA and MDNR approved Doe Run's request. Doe Run submitted to EPA and MDNR a request for an Alternative Limit for Cadmium at the Viburnum Mine/Mill via a letter dated June 6, 2012. In a letter dated August 9, 2012, EPA and MDNR approved Doe Run's request. Doe Run submitted to EPA and MDNR a request for an Alternative Limit for Cadmium at the West Fork Unit Facility, the Brushy Creek Mine/Mill and the Viburnum Mine #35 (Casteel) Facility via a letter dated August 29, 2012. Doe Run has not yet received a response from EPA or MDNR regarding this request.

104. Doe Run submitted to EPA and MDNR a Request for Extension of Alternate Limits at the Buick Resource Recycling Facility, via a letter dated March 5, 2012. In a letter dated June 6, 2012, EPA and MDNR approved Doe Run's request. Doe Run submitted to EPA and MDNR a Request for Extension of Alternate Limits at the Glover Facility, via a letter dated July 12, 2012. In a letter dated August 9, 2012, EPA and MDNR denied Doe Run's request. Doe Run may request extensions of Alternate Limits as the time frames become applicable at other CWA Facilities.

112. Doe Run submitted the Buick Used Oil Storage Tank Work Plan and related plans to EPA and MDNR via letter dated January 20, 2012. The Buick Used Oil Storage Tank Work Plan and related plans have not been approved by the EPA and MDNR during the relevant timeframe for this Semi-Annual Report

113. In accordance with subpart (c), Doe Run will begin implementation on the Buick Used Oil Storage Tank Work Plan and related plans when Doe Run receives approval from EPA and MDNR.

IX. SITE REMEDIATION – HERCULANEUM

127. This paragraph is not yet applicable. Therefore, there is nothing to report at this time.

128. Doe Run submitted to EPA and MDNR a revised Site Investigation Work Plan for the Herculaneum Lead Smelter Facility via letter dated September 24, 2012. Doe Run has not received a response from EPA or MDNR regarding the Site Investigation Work Plan during the relevant timeframe for this Semi-Annual Report.

129. This paragraph is not yet applicable. Therefore, there is nothing to report at this time.

X. FINANCIAL ASSURANCES

133. Via letters dated January 31, 2011, Doe Run submitted to EPA and MDNR an Estimated Cost of Work for each Mine/Mill Facility, a document entitled "Operating Life of Doe Run's SEMO Mine/Mill Facilities" and draft Trust Agreements for each of the Mine/Mill Facilities. EPA and MDNR have not yet approved the Estimated Cost of Work and/or draft Trust Agreements for the Mine/Mill Facilities. Thus, the remainder of this paragraph is not yet applicable.

XIV. ADDITIONAL INJUNCTIVE RELIEF

154. In accordance with this Paragraph and Appendix H, Doe Run submitted the "Enclosure of Lead Concentrate Storage and Handling for the Doe Run Brushy Creek Plant" to EPA and MDNR via letter dated July 1, 2011. Via correspondence dated September 2, 2011, EPA and MDNR stated that they did not have comments on the

Enclosure Plan. The Brushy Creek Plant Enclosure was constructed and put into continuous operation as of September 1, 2012. Doe Run submitted the "Enclosure of Lead Concentrate Storage and Handling for the Doe Run Buick Plant" to EPA and MDNR via a letter dated December 1, 2011. As Doe Run did not receive comments from EPA and MDNR within 60 days, this Enclosure Plan was deemed approved on January 30, 2012. EPA and MDNR provided comments via letter dated February 10, 2012. The Buick Plant Enclosure is currently under construction and will be completed by September 1, 2013. For those facilities that have submitted Enclosure Plans, this obligation has been completed and will not be addressed in future status reports. The remaining Enclosure Plan submissions were not required to be submitted during the relevant time frame and information will be provided in future status reports.

155. The deadlines under Appendix I have not yet been triggered. Therefore, there is nothing to report at this time.

159. The requirements under this Paragraph have not yet been triggered. Therefore, there is nothing to report at this time.

161. The requirements under this Paragraph have not yet been triggered. Therefore, there is nothing to report at this time.

165. No action has been taken by Doe Run that would trigger the obligations under this Paragraph. Therefore, there is nothing to report at this time.

XV. ENVIROMENTAL MITIGATION PROJECTS

166. The deadline under Appendix J was not during the reporting period. Therefore, there is nothing to report at this time.

Paragraph 176b. – The status of and likely target date for ceasation of operation required by Section V.

Information responsive to this requirement is discussed in the response to Section A, Paragraphs 14-18.

Paragraph 176c. – A status report of any significant problems encountered in complying with Sections V-X, XIV and XV.

The Herculaneum Lead Smelter Facility suffered a fire on March 20, 2012. Due to the fire and resulting downtime, production was shifted to the summer months and the scheduled July shutdown was cancelled. Operating the facility through the summer resulted in increased SO2 emissions: less than that allowed under the consent decree, but more than the amount that would have occurred had the shutdown happened as scheduled. Because the production and emissions limitations are on a 12-month rolling average, and the facility had very limited production in March and April 2012, this has also impacted our planned production and maintenance schedules for 2013. Doe Run has, therefore, requested that EPA allow a variance in the emission and production limits to allow the facility to return to a spring shutdown. Doe Run is currently awaiting a response to its request.

Doe Run has not encountered any other significant problems in complying with Sections V-X, XIV and XV, except as noted above or in exhibits and/or attachments attached hereto.

Paragraph 176d – A summary of the SO_2 emissions monitoring data collected pursuant to the Consent Decree, including the mass SO_2 emitted.

Information responsive to this requirement is discussed in the response to Section B, Paragraph 20, above, and in Exhibits A and B attached hereto.

Paragraph 176e – A summary of the Sinter Production data collected pursuant to the Consent Decree.

Information responsive to this requirement is discussed in the response to Section B, Paragraph 20, above, and in Exhibits A and B attached hereto.

Paragraph 176f – A summary of the Blast Furnace Sinter Consumption data collected pursuant to the Consent Decree.

Information responsive to this requirement is discussed in the response to Section B, Paragraph 20, above, and in Exhibits A and B attached hereto.

Paragraph 176g – A summary of all the Refined Lead Metal Production data collected pursuant to the Consent Decree.

Information responsive to this requirement is discussed in the response to Section B, Paragraph 20, above, and in Exhibits A and B attached hereto.

Paragraph 176h – The date and time identifying each period during which the CERMS was inoperative except for zero and span checks and the nature of any system repairs or adjustments.

There have been five periods of CERMS downtime during the reporting period for this Semi-Annual Report. The first period of CERMS downtime was the result of the fire that occurred at the Herculaneum Lead Smelter Facility on March 20, 2012. The CERMS was inoperable after smelting activities resumed on April 29, 2012 until May 18, 2012. The first period of CERMS downtime is illustrated in the "May" sheets of Exhibit AA, from cell K7 through cell K25. The second period of CERMS downtime occurred in order to conduct cleaning of the system. The second period of CERMS downtime is illustrated in the "June" sheets of Exhibit AA, from cell K11 through K13. The third period of CERMS downtime occurred in order to conduct cleaning to the system. The third period of CERMS downtime is illustrated in the "August" sheet of Exhibit AA, cell

K10. The fourth period of CERMS downtime was the result of a lighting strike that required replacement parts and calibration to the CERMS that occurred on August 16, 2012. The fourth period of CERMS downtime is illustrated in the "August" sheet of Exhibit AA, from cell K23 through cell K27. The fifth period of CERMS downtime occurred in order to conduct cleaning of the system. The fifth period of CERMS downtime is illustrated in the "August" sheet of Exhibit AA, cell K34. During the periods of downtime, Doe Run utilized substitute data pursuant to Paragraph 20.d.iv of the Consent Decree.

Paragraph 176i – All substitute data used to determine compliance with the SO_2 emission limits established in Paragraph 20.c. of the Consent Decree along with supporting calculations.

The substitute data calculations pursuant to this paragraph for the relevant time frame are attached as Exhibit AA. The spreadsheets are highlighted to indicate the date that substitute data was used. Additionally, the formula used pursuant to Paragraph 20.d.iv(b) of the Consent Decree is shown in the formula line of the sheet. For example, see the first page of Exhibit AA. Cell K7 is highlighted. The formula line states as follows:

=+Mar!$K$26/Mar!$J$26*J7

This formula is explained as follows:

"K26" of the March spreadsheet references the pounds of SO_2 measured during the previous day of operation in which the CERMS was correctly operating. "J26" of the March spreadsheet references the lead sinter produced during the previous day of operation in which the CERMS was correctly operating. "J7" references the lead sinter produced during the day of the CERMS outage. Thus, the pounds of lead sinter produced during the most recent day of operation is divided into the pounds of SO_2 measured during the most recent previous day of correct operation of the CERMS. That value is multiplied by the pounds of lead sinter produced during the date the CERMS is down. This calculation is consistent with Paragraph 20.d.iv.(b) of the Consent Decree.

Certification

I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared either by me personally or under by direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather, evaluate, and present the information therein. I further certify, based on my personal knowledge or on my inquiry of the persons who manage the system, or those persons directly responsible for gathering information, that the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

THE DOE RUN RESOUCES CORPORATION

Signature

AARON W. Miller

Print Name

Vice President of Domestic Operations and COO

Title

EXHIBIT A

Apr 2012

Reporting Day 30 | Plan Speed 49.549 | Plan Ratio 0.606 | Plan % 2nds 1.4% | Plan Yield on Charge 0.40509 | Plan tons/lot 210.1 | Plan yield on DeCu'd 99.29%

Plan tons/trk 23.8

For Month 4/1/2012 | 4 | 2012
# of Days 30 | 5/1/2012
Date of Revision
Revision #
Header Apr 2012

#Trk Conc	tons/ Trk	Day	Date	Sinter Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2 (K) Lbs	Oper Hrs	% Avail	TPH	Acid Cars	Furnace Sinter Beg Inv	Sinter Use BF 1	Sinter Use BF 2	Sinter Use Total	% 2nd's	Total Charge	DeCu'd Pump'd
0		Sun	1	3012						0.00	0.0	0.0		1535	0					
0		Mon	2	3012						0.00	0.0	0.0		1535	0					
0		Tue	3	3012						0.00	0.0	0.0		1535	0					
0		Wed	4	3012						0.00	0.0	0.0		1535	0					
0		Thu	5	3012						0.00	0.0	0.0		1535	0					
0		Fri	6	3012						0.00	0.0	0.0		1535	0					
0		Sat	7	3012						0.00	0.0	0.0		1535	0					
0		Sun	8	3012						0.00	0.0	0.0		1535	0					
0		Mon	9	3012						0.00	0.0	0.0		1535	0					
0		Tue	10	3012						0.00	0.0	0.0		1535	0					
0		Wed	11	3012						0.00	0.0	0.0		1535	0					
0		Thu	12	3012						0.00	0.0	0.0		1535	0					
0		Fri	13	3012						0.00	0.0	0.0		1535	0					
0		Sat	14	3012						0.00	0.0	0.0		1535	0					
0		Sun	15	3012						0.00	0.0	0.0		1535	0					
0		Mon	16	3012						0.00	0.0	0.0		1535	0					
0		Tue	17	3012						0.00	0.0	0.0		1535	0					
0		Wed	18	3012						0.00	0.0	0.0		1535	0					
0		Thu	19	3012						0.00	0.0	0.0	0	1535	0					
0		Fri	20	3012						0.00	0.0	0.0	0	1535	0					
0		Sat	21	3012						0.00	0.0	0.0	0	1535	0					
0		Sun	22	3012						0.00	0.0	0.0	0	1535	0					
0		Mon	23	3012						0.00	0.0	0.0	0	1535	0					
0		Tue	24	3012						0.00	0.0	0.0	0	1535	0					
0		Wed	25	3012						0.00	0.0	0.0	0	1535	0					
22	23.9	Thu	26	3012	526					0.00	0.0	0.0	0	1535	0					
0		Fri	27	3538						0.00	0.0	0.0	0	1535	0					
0		Sat	28	3538						0.00	0.0	0.0		1535	0					
0		Sun	29	3538						0.00	0.0	0.0	0	1535	0					
0		**Mon**	**30**	**3538**	**6**	**0.461**	**306**	**665**	**80**	**10.50**	**43.8**	**63.3**	**0**	**1535**	**0**		**0**	**0.0**	**0**	**0**
						0.606				0.00		49.5								
		May-1		3238.00										2200						
22		MTD Totals		(wst)	532	0.461	306	665	40	11	1.5	63.3	0		0	0	0		0	0
		MTD Totals		(dry)	492	0.426	283													
22		MthEnd Est		(wst)	532	0.461	306	665	40	10.50	1.5	63.3			0	0	0		0	0
		MthEnd Est		(dry)	492	0.426	283													
		BUDGET -		(dry)	14,365	0.562	17,185	30,587	1,610	10.50	1.5	2913.0					30,586			12,226
		Variance Est vs Plan			(13872.7)		(16902)	(29922)									(30586)			(12226)
		Forecast																		
		Variance Est vs Flash			492		283	665									0			0
		FLASH -		(dry)																
		Variance Est vs Flash			492		283	665	40								0			0

Day	Date	Refinery Lead Beg WIP	#Lots Cast	Fin Gds Cast		Day	Date	# > 15PPM	Comments	Mudd Presses
Sun	1	1125	0		24	Sun	1			
Mon	2	1125	0		24	Mon	2			
Tue	3	1125	0		24	Tue	3			
Wed	4	1125	0		24	Wed	4			
Thu	5	1125	0		24	Thu	5			
Fri	6	1125	0		24	Fri	6			
Sat	7	1125	0		24	Sat	7			
Sun	8	1125	0		24	Sun	8			
Mon	9	1125	0		24	Mon	9			
Tue	10	1125	0		24	Tue	10			
Wed	11	1125	0		24	Wed	11			
Thu	12	1125	0		24	Thu	12			
Fri	13	1125	0		24	Fri	13			
Sat	14	1125	0		24	Sat	14			
Sun	15	1125	0		24	Sun	15			
Mon	16	1125	0	-2	24	Mon	16			
Tue	17	1127	0		24	Tue	17			
Wed	18	1127	0		24	Wed	18			
Thu	19	1127	0		24	Thu	19			0
Fri	20	1127	0		24	Fri	20			0
Sat	21	1127	0		24	Sat	21			0
Sun	22	1127	0		24	Sun	22			0
Mon	23	1127	0		24	Mon	23			0
Tue	24	1127	0		24	Tue	24			0
Wed	25	1127	0		24	Wed	25			0
Thu	26	1127	0	6	24	Thu	26			0
Fri	27	1121	0		24	Fri	27			0
Sat	28	1121	0		24	Sat	28			0
Sun	29	1121	1	209	24	Sun	29	10	D6405	0
Mon	**30**	**938**	**1**	**221**	**24**	**Mon**	**30**	**9**	**C6404**	
May-1		687.50						15		
MTD Totals (wst)			2	433.8369	720					0
MTD Totals (dry)										0
MthEnd Est (wst)			2	434	720		#DIV/0!			
MthEnd Est (dry)										
BUDGET - (dry)				12,392	[illegible]					
Variance Est vs Plan				(11958.30)						
Forecast										
Variance Est vs Flash				434						
FLASH - (dry)										
Variance Est vs Flash		688		434						

May 2012

Reporting Day 31 | Plan Speed 49.549 | Plan Ratio 0.606 | Plan % 2nds 1.4% | Plan Yield on Charge 0.40509 | Plan tons/lot 210.1 | Plan yield on DeCu'd 99.29% | For Month 5/1/2012 | 5 | 2012 | # of Days 31 | 6/1/2012 | Date of Revision | Revision # | Header May 2012

Plan tons/trk 23.8

#Trk Conc	tons/ Trk	Day	Date	Sinter Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2 (K) Lbs	Oper Hrs	% Avail	TPH	Acid Cars	Furnace Sinter Beg Inv	Sinter Use BF 1	Sinter Use BF 2	Sinter Use Total	% 2nd's	Total Charge	DeCu'd Pump'd	Refinery Lead Beg WIP	#Lots Cast	Fin Gds Cast		Day	Date	# > 15PPM	Comments	Mudd Presses
18	23.7	Tue	1	3238	427	0.501	482	963	115	22.50	93.8	42.8	0	2200	483		483		483	200	688	0		24	Tue	1			
45	23.9	Wed	2	3183	1076					0.00	0.0	0.0	0	2680	83		83		83		813	1	237	24	Wed	2	6	C6406	5
8	24.1	Thu	3	4259	193	0.459	151	329	39	6.00	25.0	54.8	0	2597	496		496		496	200	563	2	425	24	Thu	3	8, 7	D6407, C6408	0
17	23.7	Fri	4	4301	403	0.601	676	1125	135	24.00	100.0	46.9	0	2430	900		900		900	200	375	0		24	Fri	4			0
42	24	Sat	5	4028	1010	0.604	586	970	116	21.00	87.5	46.2	0	2655	1100		1100		1100	400	813	1	184	24	Sat	5	11	D6409	3
0		Sun	6	4452		0.593	686	1156	138	24.00	100.0	48.2	0	2525	1216		1216		1216	400	1000	2	420	24	Sun	6	9, 12	C6411, D6410	3
0		Mon	7	3766		0.807	1034	1281	153	24.00	100.0	53.4	0	2465	1206		1206		1206	600	1125	2	408	24	Mon	7	8, 8	C6412, C6414	2
44	24	Tue	8	2732	1056	0.744	863	1160	139	23.50	97.9	49.4	0	2540	1010		1010	3.0	1040	400	1500	2	411	24	Tue	8	7, 9	D6416, C6415	0
43	24.3	Wed	9	2925	1043	0.671	713	1063	127	20.75	86.5	51.2	0	2690	1163		1163	3.4	1203	600	1500	3	651	24	Wed	9	7, 7, 8	C6417, D6419, CB6418	0
38	24.4	Thu	10	3255	928	0.772	526	681	82	15.25	63.5	44.7	0	2590	1213		1213		1213	400	1125	2	393	24	Thu	10	14, 12	CB6420, C6421	2
37	24.2	Fri	11	3657	895	0.874	1029	1177	141	24.00	100.0	49.0	4	2058	1077		1077	2.8	1107	400	1438	3	831	24	Fri	11	11, 12, 13	D6422, CB6424, CB6426	3
25	24	Sat	12	3523	601	0.525	556	1060	127	19.00	79.2	55.8		2158	1160		1160	2.6	1190	600	1313	2	420	24	Sat	12	8, 7	C6425, C6427	0
0		Sun	13	3568		0.610	787	1290	154	24.00	100.0	53.8		2058	1190		1190	2.5	1220	400	1438	2	430	24	Sun	13	9, 12	C6428, C6429	2
0		Mon	14	2781		0.601	635	1057	127	21.25	88.5	49.7		2158	1330		1330		1330	600	1500	3	636	24	Mon	14	13, 13, 13	C6430, D6431, D6433	0
55	23.9	Tue	15	2146	1316	0.716	841	1175	141	24.00	100.0	49.0	5	1885	1250		1250	2.4	1280	400	1313	3	684	24	Tue	15	13,22,18	D6432, C6436, D6435	0
37	24.1	Wed	16	2621	892	0.763	1031	1352	162	23.50	97.9	57.5	3	1810	1027		1027	1.9	1047	600	1250	2	468	24	Wed	16	14, 10	CB6438, C6439	0
35	24.1	Thu	17	2482	843	0.898	591	658	79	15.00	62.5	43.9	6	2135	983		983		983	400	1500	3	720	24	Thu	17	15, 11, 14	D6437, D6440, CB6443	0
42	24.1	Fri	18	2734	1013	0.668	772	1155	138	24.00	100.0	48.1	5	1810	1145		1145	2.2	1170	400	1250	2	455	24	Fri	18	16, 13	CB6442, CB6445	0
59	24	Sat	19	2975	1417	0.673	828	1231	147	22.75	94.8	54.1	5	1820	1124		1124	2.7	1154	400	1313	2	444	24	Sat	19	12,12	D6434, C6446	5
27	24.3	Sun	20	3564	656	0.576	686	1191	172	22.50	93.8	52.9	0	1927	1141		1141		1141	400	1375	2	467	24	Sun	20	8,9	C6448, C6450	0
0		Mon	21	3534		0.644	876	1360	163	24.00	100.0	56.7	0	1977	1085		1085		1085	400	1438	2	610	24	Mon	21	11,9,9	D6447, D6449, D6452	0
40	23.5	Tue	22	2658	938	0.677	689	1017	156	21.75	90.6	46.8	4	2252	967		967	3.1	997	400	1500	2	477	24	Tue	22	9,8	C6453, D6454	0
42	23.8	Wed	23	2907	1012	0.728	820	1126	156	22.00	91.7	51.2	4	2302	1041		1041	2.9	1071	400	1375	3	638	24	Wed	23	11, 10, 10	C6451, D6456, D6455	0
37	24.1	Thu	24	3099	890	0.718	509	709	79	12.00	50.0	59.1	0	2387	1097		1097		1097	400	1125	2	462	24	Thu	24	10,9	D6458, C6457	0
31	24.3	Fri	25	3480	753	0.455	394	866	139	20.50	85.4	42.2	0	1999	1141		1141	2.6	1171	400	1063	2	449	24	Fri	25	11, 12	D6460, C6461	0
40	24.1	Sat	26	3839	964	0.635	699	1101	146	22.50	93.8	48.9	0	1724	1051		1051	2.9	1081	400	1250	2	446	24	Sat	26	18, 12	D6462, C6463	0
0		Sun	27	4104		0.790	908	1150	155	24.00	100.0	47.9	0	1774	1200		1200		1200	400	1250	2	418	24	Sun	27	12, 14	D6465, C6464	0
0		Mon	28	3196		0.754	762	1011	159	24.00	100.0	42.1	0	1724	1201		1201		1201	600	1375	2	405	24	Mon	28	14, 15	C6466, D6468	0
0			29	2434		0.539	774	1437	157	24.00	100.0	59.9	0	1534	1207		1207		1207	400	1500	3	664	24	Tue	29	8, 9, 11	D6469, D6467, C6470	0
52	23.8	Wed	30	1660	1239	0.778	937	1205	160	24.00	100.0	50.2	2	1764	1180		1180	1.7	1200	400	1438	3	699	24	Wed	30	10, 7, 6	C6471, D6473, D6472	0
48	**24**	**Thu**	**31**	**1962**	**1303**	**0.584**	**675**	**959**	**130**	**17.50**	**72.9**	**51.3**	**1**	**1789**	**1128**		**1128**	**0.0**	**1128**	**600**	**1313**	**3**	**605**	**24**	**Thu**	**31**	**9, 12, 14**	**C6475, D6476, C6477**	8
	June-1			2590										1620							1375.00						17		
862	MTD Totals	(wst)			20868	0.672	21516	32015	2016	637	85.7	50.2	39		32595	0	32595	1.2	33000	12800		65	14557.3186	744					25
	MTD Totals	(dry)			19303	0.622	19902																						0.80645161 3
862	MthEnd Est	(wst)			20868	0.672	21516	32015	2016	637.25	85.7	50.2			32595	0	32595	1.2	33000	12800		65	14558	744	0.3927				
	MthEnd Est	(dry)			19302.6275	0.622	19902																						
	BUDGET -	(dry)			17,879	0.562	18,593	33,092	1,718	637.25	85.7	51.9					33,092			13,227			13,181						
	Variance Est vs Plan				1423.6		1309	(1077)									(497)			(427)			1376.63						
	Forecast																												
	Variance Est vs Flash				19303		19902	32015									32595			12800			14558						
	FLASH -	(dry)			18,979		19,844	32,064	1,912					1706			32,558			12,636	1221.76		14,454						
	Variance Est vs Flash				324		58	(49)	104					(86)			37			164	153		104						

Reporting Day	30		June 2012	Plan Speed	49.549	Plan % 2nds	1.4%	Plan tons/lot	210.1	For Month	6/1/2012	6	2012
Plan tons/trk	23.8			Plan Ratio	0.606	Plan Yield on Charge	0.40509	Plan yield on DeCu'd	99.29%	# of Days	30	7/1/2012	
										Date of Revision			
										Revision #			
										Header	June 2012		

Sinter

#Trk Conc	tons/ Trk	Day	Date	Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2 (K) Lbs	Oper Hrs	% Avail	TPH	Acid Cars
33	23.9	Fri	1	2590	789	0.495	605	1221	181	23.50	97.9	52.0	2
46	23.8	Sat	2	2774	1093	0.604	813	1345	186	24.00	100.0	56.0	0
0		Sun	3	3054		0.728	1010	1387	195	24.00	100.0	57.8	0
0		Mon	4	2044		0.597	854	1430	135	24.00	100.0	59.6	0
44	23.7	Tue	5	1190	1042	0.660	155	235	22	6.50	27.1	36.2	0
46	23.8	Wed	6	2077	1097	0.551	601	1090	103	14.25	59.4	76.5	0
55	24.1	Thu	7	2573	1323	0.785	716	912	86	24.00	100.0	38.0	0
34	23.8	Fri	8	3180	810	0.563	651	1156	168	23.00	95.8	50.3	0
44	24.1	Sat	9	3339	1059	0.497	469	943	155	20.75	86.5	45.4	0
0		Sun	10	3929		0.585	647	1106	174	22.50	93.8	49.2	0
0		Mon	11	3282		0.584	766	1311	195	24.00	100.0	54.6	0
36	23.8	Tue	12	2516	856	0.669	751	1122	190	24.00	100.0	46.8	0
50	23.9	Wed	13	2621	1193	0.713	856	1200	165	24.00	100.0	50.0	0
33	24.1	Thu	14	2958	795	0.564	159	282	22	3.00	12.5	94.0	0
53	23.8	Fri	15	3594	1260	0.718	798	1112	179	24.00	100.0	46.3	2
39	23.9	Sat	16	4056	933	0.684	659	963	175	23.25	96.9	41.4	0
0		Sun	17	4330		0.684	714	1044	172	22.75	94.8	45.9	0
0		Mon	18	3616		0.556	644	1158	179	22.75	94.8	50.9	0
36	23.9	Tue	19	2972	859	0.494	613	1241	168	21.25	88.5	58.4	0
33	24.1	Wed	20	3218	794	0.583	582	999	181	24.00	100.0	41.6	0
0		Thu	21	3430		1.013	383	378	62	6.00	25.0	63.0	3
22	23.7	Fri	22	3047	522	0.419	473	1129	190	24.00	100.0	47.0	0
29	24.1	Sat	23	3096	699	0.569	631	1109	182	24.00	100.0	46.2	1
0		Sun	24	3164		0.549	591	1077	168	22.75	94.8	47.3	0
0		Mon	25	2573		0.644	631	980	180	24.00	100.0	40.8	0
51	23.9	Tue	26	1942	1220	0.781	427	547	109	14.00	58.3	39.1	0
28	24.1	Wed	27	2735	676	0.572	649	1127	174	20.50	85.4	55.0	0
40	24.1	Thu	28	2766	963	1.034	393	380	59	7.50	31.3	50.7	0
42	24	Fri	29	3336	1006	0.590	628	1064	189	24.00	100.0	44.3	0
39	**27.8**	**Sat**	**30**	**3714**	**1085**	**0.766**	**763**	**996**	**189**	**23.25**	**96.9**	**42.8**	
						0.606				0.00		49.5	
	July-1			4036	3733								
833	MTD Totals	(wst)			20074	0.620	18628	30044	2265	610	84.7	49.3	8
	MTD Totals	(dry)			18568.5850	0.574	17231.0400						
833	MthEnd Est	(wst)			20074	0.620	18628	30044	2265	609.50	84.7	49.3	
	MthEnd Est	(dry)			18569	0.574	17231						
	BUDGET -	(dry)			17,066	0.562	17,414	30,994	1,625	609.50	84.7	50.9	
	Variance Est vs Plan				1502.6		(183)	(950)					
	Forecast												
	Variance Est vs Flash				18569		17231	30044					
	FLASH -	(dry)			18,344		17,871	30,244	2,249				
	Variance Est vs Flash				225		160	(200)	16				

Furnace / Refinery

Date	Sinter Beg Inv	Sinter Use BF 1	Sinter Use BF 2	Sinter Use Total	% 2nd's	Total Charge	DeCu'd Pump'd	Lead Beg WIP	#Lots Cast	Fin Gds Cast		Day	Date	# > 15PPM	Comments	Mudd Presses
1	1620	946		946		946	200	1375	2	452	24	Fri	1	12, 10	D6479, C6478	3
2	1895	1195		1195		1195	400	1063	2	385	24	Sat	2	14, 11	D6480, C6481	5
3	2045	1187		1187		1187	600	1375	2	410	24	Sun	3	9, 9	C6482, D6483	8
4	2245	1155		1155		1155	400	1438	2	459	24	Mon	4	5, 9	D6485, C6484	4
5	2520	917		917		917	400	1438	3	727	24	Tue	5	6, 6, 7	D6486, D6488, C6486	2
6	1838	990		990	2.0	1010	400	1188	2	455	24	Wed	6	11, 7	D6491, C6490	0
7	1938	1102		1102	2.7	1132	400	1250	2	454	24	Thu	7	11, 8	D6493, C6492	4
8	1748	1081		1081	4.6	1131	400	1313	3	670	24	Fri	8	6,9,9	D6495, D6494, CB6497	6
9	1823	1166		1166		1166	400	1250	2	429	24	Sat	9	8, 8	D6498, D6499	1
10	1600	1056		1056		1056	400	1188	2	484	24	Sun	10	9, 13	D6496, D6502	2
11	1650	1186		1186		1186	400	1250	2	361	24	Mon	11	9, 10	D6500, C6503	2
12	1775	1097		1097	1.8	1117	400	1250	2	469	24	Tue	12	11, 10	D6504, C6505	7
13	1800	170		170		170	200	1313	3	717	24	Wed	13	7, 6, 7	C6507, D6508, D6505	4
14	2830	657		657		657	200	688	1	216	24	Thu	14	8	C6510	11
15	2455	1087		1087		1087	400	813	2	437	24	Fri	15	10, 8	D6511, C6512	0
16	2480	1088		1088	4.6	1138	400	875	1	244	24	Sat	16	10	CB6514	6
17	2355	1069		1069	1.9	1089	400	1188	2	409	24	Sun	17	8, 8	C6515, CB6516	0
18	2330	1108		1108	0.5	1113	400	1188	2	460	24	Mon	18	9, 9	C6517, D6518	0
19	2380	1085		1085	1.4	1100	400	1188	2	463	24	Tue	19	11, 6	C6519. D6521	0
20	2536	1099		1099		1099	600	1125	2	425	24	Wed	20	14, 12	C6522, D6520	0
21	2436	628		628		628	200	1250	1	234	24	Thu	21	12	C6523	0
22	2186	1022		1022	2.0	1042	400	1375	2	423	24	Fri	22	10, 11	C6527, D6525	0
23	2293	1109		1109	2.7	1139	400	1313	2	433	24	Sat	23	8, 13	C6526, D6528	0
24	2293	1127		1127	3.1	1162	400	1250	2	433	24	Sun	24	12, 8	D6529, C6531	0
25	2243	1005		1005	3.0	1035	400	1250	2	488	24	Mon	25	12, 14	D6530, D6532	3
26	2218	1066		1066	1.9	1086	400	1375	2	389	24	Tue	26	9,8	C6533, C6534	2
27	1699	1032		1032	1.9	1052	400	1375	2	448	24	Wed	27	6, 13	D6536, C6538	0
28	1794	1039		1039	1.2	1051	400	1375	2	345	24	Thu	28	8, 13	D6540, C6539	1
29	1135	1089		1089		1089	400	1375	2	462	24	Fri	29	10, 10	D6543, C6541	0
30	**1110**	**1083**		**1083**	**1.4**	**1098**	**445**	**1500**	**3**	**657**	**24**	**Sat**	**30**			
July-1	1023							1521.00						30		
MTD Totals (wst)		30641	0	30641	1.3	31033	11645		61	13438.5136	720					71
MTD Totals (dry)																2.366666667
MthEnd Est (wst)		30641	0	30641	1.3	31033	11645		61	13439	720	0.38004				
MthEnd Est (dry)																
BUDGET - (dry)				30,994			12,389			12,345						
Variance Est vs Plan				(353)			(744)			1093.63						
Forecast																
Variance Est vs Flash				30641			11645			13439						
FLASH - (dry)	1185			30,679			11,699	1198.84		13,421						
Variance Est vs Flash	(162)			(38)			(54)	322		18						

July 2012

Reporting Day 31

Plan tons/trk 23.8

Plan Speed 49.47
Plan Ratio 0.606

Plan % 2nds 1.4%
Plan Yield on Charge 0.40509

Plan tons/lot 210.1
Plan yield on DeCu'd 99.29%

For Month 7/1/2012 7
# of Days 31 8/1/2012
Date of Revision
Revision #
Header July 2012

Sinter | **Furnace** | **Refinery**

#Trk Conc	tons/Trk	Day	Date	Sinter Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2(K) Lbs	Oper Hrs	% Avail	TPH	Acid Cars	Sinter Beg Inv	Sinter Use BF 1	BF 2	Total	% 2nd's	Total Charge	DeCu'd Pump'd	Lead Beg WIP	#Lots Cast	Fin Gds Cast		Day	Date	# > 15PPM	Comments	Mudd Presses
0		Sun	1	4036		0.554	667	1205	198	24.00	100.0	50.2	0	1023	1135		1135		1135	400	1521	2	439	24	Sun	1	10, 7	C6546, D6548	0
0		Mon	2	3369		0.606	721	1189	211	23.75	99.0	50.1	0	1093	1144		1144		1144	600	1313	1	231	24	Mon	2	8	CB6549	0
41	24	Tue	3	2648	984	0.626	646	1032	186	20.50	85.4	50.3	0	1138	890		890		890	400	1688	2	403	24	Tue	3	11, 10	D6552, C6550	7
55	24	Wed	4	2986	1320	0.779	450	578	87	13.25	55.2	43.6	1	1280	928		928		928	400	1750	3	633	24	Wed	4	11, 8, 15	D6553, D6551, C6554	5
0		Thu	5	3856		0.624	707	1133	201	24.00	100.0	47.2	0	930	1083		1083	0.5	1088	400	1500	3	645	24	Thu	5	11, 14, 8	D6556, D6557, D6558	5
51	23.9	Fri	6	3149	1217	0.609	751	1233	204	24.00	100.0	51.4	4	980	1058		1058	1.9	1078	400	1250	2	476	24	Fri	6	11, 9	D6559, C6560	2
49	24.1	Sat	7	3615	1179	0.551	519	942	161	19.25	80.2	48.9	3	1155	1092		1092		1092	400	1313	2	437	24	Sat	7	10, 14	D6561, D6562	0
0		Sun	8	4275		0.618	677	1096	206	24.00	100.0	45.7	0	1005	1094		1094		1094	600	1250	2	351	24	Sun	8	13, 14	C6563, C6564	0
0		Mon	9	3598		0.702	873	1244	207	24.00	100.0	51.8	0	1007	1094		1094	1.4	1109	400	1375	1	230	24	Mon	9	13	D6565	0
33	24.2	Tue	10	2725	797	0.627	685	1093	193	21.75	90.6	50.3	1	1157	1133		1133	2.2	1158	400	1625	3	602	24	Tue	10	13, 9, 11	C6566, D6567, C6569	4
40	24	Wed	11	2837	961	0.926	780	842	193	20.50	85.4	41.1	2	1117	1117		1117		1117	400	1438	3	653	24	Wed	11	8, 10, 9	D6570, CB6568, C6572	2
37	24.1	Thu	12	3018	890	0.630	692	1099	196	20.50	85.4	53.6	0	842	1124		1124		1124	600	1313	2	407	24	Thu	12	10, 10	C6571, C6574	0
33	24	Fri	13	3216	792	0.665	670	1007	202	18.25	76.0	55.2	3	817	957		957		957	400	1500	2	475	24	Fri	13	12, 12	D6576, C6575	0
36	23.9	Sat	14	3338	861	0.667	706	1058	208	20.00	83.3	52.9	5	867	1008		1008	1.0	1018	400	1688	3	607	24	Sat	14	12, 13, 10	C6577, D6578, C6579	0
0		Sun	15	3493		0.629	350	556	177	11.00	45.8	50.5	0	917	998		998		998	400	1250	1	192	24	Sun	15	8	CB6581	2
0		Mon	16	3143					6	0.00	0.0	0.0	0	475	0					200	1688	2	413	24	Mon	16	11, 10	C6580, C6583	0
29	23.4	Tue	17	3143	680				0	0.00	0.0	0.0	4	475	0						1125	2	433	24	Tue	17	14, 14	C6582, C6584	0
0		Wed	18	3823					0	0.00	0.0	0.0	1	475	0						750	1	199	24	Wed	18	12	C6585	0
28	24	Thu	19	3823	672				0	0.00	0.0	0.0	0	475	0						625	1	189	24	Thu	19	13	C6586	0
0		Fri	20	4495					0	0.00	0.0	0.0	1	475	0						375	1	212	24	Fri	20	13	D6573	0
19	24.2	Sat	21	4495	459				0	0.00	0.0	0.0	5	475	0						188	0		24	Sat	21			0
0		Sun	22	4954					0	0.00	0.0	0.0	0	475	0						250	0		24	Sun	22			0
0		Mon	23	4954		0.680	85	125	7	3.25	13.5	38.5	0	475	0						250	0	-14	24	Mon	23			0
43	23.9	Tue	24	4869	1027	0.548	713	1300	165	23.75	99.0	54.7	0	600	0						264	0	70	24	Tue	24			0
0		Wed	25	5183		0.742	415	559	134	16.75	69.8	33.4	2	1900	907		907		907	200	313	0	25	24	Wed	25			0
31	23.9	Thu	26	4768	740	0.737	676	917	102	16.00	66.7	57.3	2	1552	1043		1043		1043	400	688	1	237	24	Thu	26	9	C6588	0
28	24.1	Fri	27	4832	676	0.648	688	1062	175	22.75	94.8	46.7	4	1426	1112		1112		1112	400	1000	1	16	24	Fri	27	8	D6589	0
37	24.2	Sat	28	4820	894	0.624	776	1243	207	24.00	100.0	51.8	0	1376	1093		1093		1093	400	1375	3	637	24	Sat	28	9, 10, 7	D6589, D6591, CB6593	0
0		Sun	29	4938		0.587	716	1219	178	21.50	89.6	56.7	0	1526	1119		1119		1119	400	1063	2	423	24	Sun	29	8, 10	CB6594, C6596	0
0		Mon	30	4222		0.685	820	1197	189	24.00	100.0	49.9	0	1626	1112		1112		1112	400	1063	2	375	24	Mon	30	13, 6	C6597, C6598	0
42	**27**	**Tue**	**31**	**3402**	**1120**	**0.941**	**915**	**972**	**179**	**22.00**	**91.7**	**44.2**	**2**	**1711**	**1090**		**1090**	**2.8**	**1120**	**400**	**1063**	**2**	**521**	**24**	**Tue**	**31**	**7, 8**	**D6600, D6595**	1
		August-1		3607										1591.00							1520.00						84		
632		MTD Totals	(wst)		15269	0.657	15698	23901	2087	483	64.9	49.51	40		23331	0	23331	0.5	23436	9400		50	10516.4705	744					27
		MTD Totals	(dry)		14124	0.608	14521																						0.870967742
632		MthEnd Est	(wst)		15269	0.657	15698	23901	2087	482.75	64.9	49.51			23331	0	23331	0.5	23436	9400		50	10516	744	0.4029				
		MthEnd Est	(dry)		14124	0.608	14521																						
		BUDGET -	(dry)		8,698	0.562	1,689	3,005	159	482.75	64.9	6.2					3,006			1,201			1,747.65						
		Variance Est vs Plan			5425.9		12832	20896									20325			8199			8768.82						
		Forecast																											
		Variance Est vs Flash			14124		14521	23901									23331			9400			10516						
		FLASH -	(dry)		14,257		13,804	23,574	1,923					1360 9775			23,236			9,588	915.08		10,633						
		Variance Est vs Flash			(133)		717	327	163					232			95			(180)	605		(117)						

August 2012

Reporting Day	31	Plan Speed	52.8	Plan % 2nds	1.4%	Plan tons/lot	210.1	For Month	8/1/2012	8	2012
Plan tons/trk	23.8	Plan Ratio	0.606	Plan Yield on Charge	0.40509	Plan yield on DeCu'd	99.29%	# of Days	31	9/1/2012	
								Date of Revision			
								Revision #			
								Header	August 2012		

Sinter

#Trk Conc	tons/ Trk	Day	Date	Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2 (K) Lbs	Oper Hrs	% Avail	TPH	Acid Cars
51	24.2	Wed	1	3607	1235	0.607	683	1126	176	24.00	100.0	46.9	3
25	24	Thu	2	4159	601	0.706	334	473	85	10.50	43.8	45.0	0
0		Fri	3	4426		0.719	794	1104	157	20.00	83.3	55.2	0
44	24	Sat	4	3632	1058	0.558	656	1175	167	23.00	95.8	51.1	0
0		Sun	5	4034		0.634	799	1261	135	24.00	100.0	52.5	0
0		Mon	6	3235		0.597	758	1270	152	24.00	100.0	52.9	0
36	24.2	Tue	7	2477	872	0.591	792	1340	168	24.00	100.0	55.8	0
35	24.2	Wed	8	2557	846	0.611	731	1196	152	22.50	93.8	53.2	0
43	23.5	Thu	9	2672	1010	0.744	480	645	59	10.25	42.7	62.9	0
32	24.2	Fri	10	3202	773	0.601	757	1260	162	24.00	100.0	52.5	0
49	24	Sat	11	3218	1174	0.750	769	1025	152	24.00	100.0	42.7	0
0		Sun	12	3623		0.639	765	1197	150	24.00	100.0	49.9	0
0		Mon	13	2858		0.756	1002	1326	159	24.00	100.0	55.3	0
36	24.2	Tue	14	1856	871	0.605	656	1085	121	19.75	82.3	54.9	2
50	24.1	Wed	15	2071	1203	0.631	706	1119	137	24.00	100.0	46.6	0
44	23.8	Thu	16	2568	1045	0.710	606	853	101	16.50	68.8	51.7	1
52	23.9	Fri	17	3007	1241	0.569	717	1261	150	24.00	100.0	52.5	5
43	24.4	Sat	18	3531	1048	0.712	666	935	111	15.00	62.5	62.3	2
0		Sun	19	3913		0.600	599	999	119	22.75	94.8	43.9	0
0		Mon	20	3314		0.757	887	1171	139	23.00	95.8	50.9	0
45	24	Tue	21	2427	1079	0.732	928	1268	151	24.00	100.0	52.8	4
55	24	Wed	22	2578	1318	0.622	667	1073	144	18.00	75.0	59.6	1
31	24.2	Thu	23	3229	750	0.783	578	738	101	14.00	58.3	52.7	2
32	24.2	Fri	24	3401	773	0.679	602	887	171	20.00	83.3	44.4	1
50	24	Sat	25	3572	1199	0.709	792	1117	161	22.00	91.7	50.8	0
0		Sun	26	3979		0.718	668	930	176	21.25	88.5	43.8	0
0		Mon	27	3311		0.709	605	853	147	18.00	75.0	47.4	0
42	23.7	Tue	28	2706	995	0.694	671	967	167	20.75	86.5	46.6	3
53	23.8	Wed	29	3030	1260	0.519	654	1260	168	21.00	87.5	60.0	0
40	24	Thu	30	3636	961	0.750	587	783	135	20.00	83.3	39.2	1
31	**27**	**Fri**	**31**	**4010**	**836**	**0.808**	**925**	**1145**	**149**	**22.50**	**93.8**	**50.9**	**3**
	September-1			3921	3627								
919	MTD Totals	(wet)			22148	0.665	21834	32842	2210	645	86.7	50.9	28
	MTD Totals	(dry)			20486.6400	0.615	20196						
919	MthEnd Est	(wet)			22148	0.665	21834	32842	2210	644.75	86.7	50.9	
	MthEnd Est	(dry)			20487	0.615	20196						
	BUDGET -	(dry)			12,124	0.562	17,310	30,808	1,624	644.75	86.7	47.8	
	Variance Est vs Plan				8362.6		2886	2034					
	Forecast				18,691		18,384	32,721	1,945				
	Variance Est vs Flash				1796		1812	121					
	FLASH -	(dry)			19,873		20,004	32,885	2,194				
	Variance Est vs Flash				614		192	(43)	16				

Furnace / Refinery

Day	Date	Furnace Sinter Beg Inv	Sinter Use BF 1	Sinter Use BF 2	Sinter Use Total	% 2nd's	Total Charge	DeCu'd Pump'd	Refinery Lead Beg WIP	#Lots Cast	Fin Gds Cast	
Wed	1	1593	1101		1101	1.4	1116	400	1520	2	416	24
Thu	2	1618	1003		1003		1003	400	1500	2	408	24
Fri	3	1088	1180		1180	2.1	1205	400	1375	2	437	24
Sat	4	1012	1125		1125		1125	600	1625	3	636	24
Sun	5	1062	1061		1061		1061	400	1500	2	424	24
Mon	6	1262	1220		1220		1220	600	1375	2	347	24
Tue	7	1312	1090		1090	3.7	1130	400	1500	2	476	24
Wed	8	1562	1071		1071	1.9	1091	400	1563	3	572	24
Thu	9	1687	1063		1063	4.2	1108	400	1500	3	523	24
Fri	10	1269	1050		1050	5.7	1110	600	1500	2	436	24
Sat	11	1479	1085		1085	2.0	1107	400	1500	2	407	24
Sun	12	1419	1147		1147	0.3	1150	400	1500	2	384	24
Mon	13	1469	1176		1176	0.6	1183	400	1438	2	438	24
Tue	14	1619	1060		1060	2.3	1084	600	1750	3	710	24
Wed	15	1644	994		994	1.0	1004	400	1563	3	611	24
Thu	16	1769	1130		1130	1.8	1150	400	1313	3	650	24
Fri	17	1492	1136		1136	1.8	1156	600	1313	1	245	24
Sat	18	1617	935		935		935	600	1438	2	363	24
Sun	19	1617	1099		1099	4.5	1149	400	1438	3	611	24
Mon	20	1517	1151		1151	3.5	1191	600	1438	2	457	24
Tue	21	1537	1163		1163		1163	400	1500	3	621	24
Wed	22	1642	1148		1148		1148	600	1313	2	448	24
Thu	23	1567	894		894		894	400	1500	2	453	24
Fri	24	1411	1037		1037	2.4	1062	400	1563	3	634	24
Sat	25	1261	1042		1042	2.9	1072	400	1375	2	369	24
Sun	26	1336	1155		1155		1155	400	1500	3	635	24
Mon	27	1111	1143		1143		1143	600	1563	3	601	24
Tue	28	821	1100		1100	3.6	1140	400	1250	2	344	24
Wed	29	688	936		936	9.1	1021	600	1625	2	393	24
Thu	30	1012	958		958	3.1	988	400	1438	3	585	24
Fri	**31**	**837**	**1083**		**1083**	**0.6**	**1090**	**400**	**1250**	**2**	**638**	**24**
September-1		899							1595			
MTD Totals (wet)			33536	0	33536	1.8	34154	14400		73	15273.1590	744
MTD Totals (dry)												[illegible]
MthEnd Est (wet)			33536	0	33536	1.8	34154	14400		73	15273.16	744
MthEnd Est (dry)												[illegible]
BUDGET - (dry)					30,808			12,314			11,721.02	[illegible]
Variance Est vs Plan					2728			2086			3552.14	
Forecast					32,794			12,652			11,773	[illegible]
Variance Est vs Flash					742			1748			3500	
FLASH - (dry)		674			33,804			14,332	1555		15,000	[illegible]
Variance Est vs Flash		225			(268)			68	40		273.16	

Daily Log

Day	Date	# > 15PPM	Comments	Mudd Presses
Wed	1			
Thu	2	13, 6	C6602, D6605	1
Fri	3	17, 9	C6604, C6606	0
Sat	4	13, 11, 13	D6607, D6609, D6611	4
Sun	5	10, 14	C6610, CB6612	1
Mon	6	10, 11	C6613, C6615	0
Tue	7	11, 11	D6614, C6616	1
Wed	8	11, 9, 6	C6617, D6619, D6618	4
Thu	9	7, 19, 8	D6622, D6623, C6620	3
Fri	10	8, 11	C6621, D6625	2
Sat	11	12, 15	C6626, CB6624	3
Sun	12	10, 8	C6628, C6629	4
Mon	13	9, 9	C6631, D6630	0
Tue	14	10, 12, 7	C6632, D6634, D6635	0
Wed	15	11, 11, 13	C6637, D6636, D6638	2
Thu	16	13, 12, 13	CB6639, C6640, D6642	4
Fri	17	11	C6641	0
Sat	18	15, 12	C6644, D6645	3
Sun	19	11, 11, 12	C6646, D6648, C6647	1
Mon	20	9, 11	CB6649, C6650	2
Tue	21	11, 12, 10	C6653, D6652, D6654	1
Wed	22	9, 10	D6655, CB6656	0
Thu	23	13, 7	D6658, C6657	4
Fri	24	9, 12, 11	C6659, D6662, D6661	0
Sat	25	14, 9	C6660, C6664	4
Sun	26	8, 11, 9	D6667, C6663, D6665	2
Mon	27	8, 8, 9	C6666, D6671, C6668	3
Tue	28	9, 9	C6670, C6672	2
Wed	29	10, 10	CB6665, C6673	0
Thu	30	12, 15, 13	D6675, CB6674, D6676	1
Fri	**31**	**10, 9**	**C6679, D6677**	7
		11		
				59
				1.90322580€
	0.42939			

September 2012

Reporting Day: 30

Plan tons/trk: 23.8

Plan Speed: 50.833 | Plan Ratio: 0.606

Plan % 2nds: 1.4% | Plan Yield on Charge: 0.40509

Plan tons/lot: 210.1 | Plan yield on DeCu'd: 99.29%

For Month: 9/1/2012 | 9 | 2012
# of Days: 30 | 10/1/2012
Date of Revision
Revision #
Header: September 2012

Sinter

#Trk Conc	tons/Trk	Day	Date	Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2(K) Lbs	Oper Hrs	% Avail	TPH	Acid Cars
26	24.1	Sat	1	3921	627	0.685	828	1208	183	24.00	100.0	50.3	0
		Sun	2	3720		0.731	686	938	139	16.75	69.8	56.0	0
		Mon	3	3034		0.633	639	1009	176	21.00	87.5	48.0	0
		Tue	4	2395		0.695	155	223	40	0.00	0.0	0.0	0
20	23.9	Wed	5	2240	478				3	0.00	0.0	0.0	0
		Thu	6	2718						0.00	0.0	0.0	0
37	24	Fri	7	2718	889				0	0.00	0.0	0.0	3
29	24.1	Sat	8	3607	698					0.00	0.0	0.0	3
		Sun	9	4305						0.00	0.0	0.0	0
		Mon	10	4305		0.834	292	350	34	8.75	36.5	40.0	0
33	23.9	Tue	11	4013	788	0.586	662	1130	138	22.50	93.8	50.2	0
43	24.1	Wed	12	4139	1038	0.726	822	1132	153	23.75	99.0	47.7	0
		Thu	13	4355		0.538	601	1117	142	21.25	88.5	52.6	0
28	23.9	Fri	14	3754	670	0.668	773	1158	131	20.75	86.5	55.8	5
26	24	Sat	15	3651	623	0.770	851	1105	148	24.00	100.0	46.0	2
		Sun	16	3423		0.680	768	1129	153	24.00	100.0	47.0	0
		Mon	17	2655		0.803	756	941	105	17.50	72.9	53.8	0
40	24.3	Tue	18	1899	970	0.765	736	962	134	22.25	92.7	43.2	0
39	24.2	Wed	19	2133	945	0.620	607	979	131	18.25	76.0	53.6	2
38	24.2	Thu	20	2471	921	0.731	839	1147	158	24.00	100.0	47.8	2
32	24	Fri	21	2553	767	0.736	849	1154	138	23.50	97.9	49.1	3
45	24	Sat	22	2471	1081	0.741	611	825	105	14.75	61.5	55.9	1
		Sun	23	2941		0.609	627	1029	146	24.00	100.0	42.9	0
		Mon	24	2314		0.595	814	1369	163	24.00	100.0	57.0	0
45	24	Tue	25	1500	1079	0.662	659	996	125	19.50	81.3	51.1	0
33	24	Wed	26	1920	792	0.759	464	611	86	13.25	55.2	46.1	0
35	23.9	Thu	27	2248	836	0.690	861	1247	159	24.00	100.0	52.0	0
31	23.9	Fri	28	2223	742	0.764	698	914	123	16.75	69.8	54.6	0
43	23.8	Sat	29	2267	1022	0.589	710	1206	160	24.00	100.0	50.3	
0		**Sun**	**30**	**2579**	**66**	**0.818**	**842**	**1030**	**118**	**19.75**	**82.3**	**52.2**	
						0.606				0.00		50.8	
		October-1		1803									
623		MTD Totals	(wst)		15032	0.689	17150	24909	1645	492	68.4	50.6	21
		MTD Totals	(dry)		13905	0.637	15864						
623		MthEnd Est	(wst)		15032	0.689	17150	24909	1645	492.25	68.4	50.6	
		MthEnd Est	(dry)		13905	0.637	15864						
		BUDGET -	(dry)		16,253	0.562	18,368	32,692	1,686	492.25	68.4	66.4	
		Variance Est vs Plan			(2348.1)		(2504)	(7783)					
		Forecast											
		Variance Est vs Flash			13905		15864	24909					
		FLASH -	(dry)		13,708		15,353	24,736	1,603				
		Variance Est vs Flash			197		511	173	42				

Furnace / Refinery

Date	Sinter Beg Inv	Sinter Use BF 1	Sinter Use BF 2	Sinter Use Total	% 2nd's	Total Charge	DeCu'd Pump'd	Lead Beg WIP	#Lots Cast	Fin Gds Cast
1	899	1115		1115	1.4	1131	600	1595	2	409
2	992	1063		1063	0.9	1073	400	1438	2	431
3	867	884		884	3.4	914	600	1625	2	396
4	992	797		797	1.6	810	400	1375	2	384
5	418	0					100	1500	1	206
6	418	0						1313	1	220
7	418	0						1250	1	216
8	418	0						1125	1	164
9	418	0						938	2	218
10	418	0						500	1	197
11	768	655		655		655	200	313	0	
12	1243	1157		1157	3.9	1202	400	563	0	
13	1218	1142		1142	0.9	1152	400	1188	1	258
14	1193	1158		1158		1158	600	1375	2	479
15	1193	1120		1120	2.7	1150	400	1438	3	656
16	1178	1107		1107	3.6	1147	600	1313	2	447
17	1200	1041		1041		1041	400	1500	2	433
18	1100	1085		1085	0.9	1095	400	1375	2	411
19	977	1061		1061		1061	400	1563	2	445
20	895	1047		1047	5.1	1100	600	1563	3	693
21	995	954		954	7.3	1024	400	1313	2	470
22	1195	925		925	1.6	940	400	1375	2	393
23	1095	1079		1079	3.7	1119	600	1188	2	444
24	1045	1169		1169		1169	400	1500	2	402
25	1245	1046		1046	2.9	1076	600	1563	2	483
26	1195	861		861	1.7	876	400	1563	3	673
27	945	1122		1122		1122	600	1375	2	415
28	1070	1059		1059		1059	400	1438	3	634
29	925	1131		1131		1131	600	1375	2	379
30	**1000**	**1067**		**1067**	**0.0**	**1067**	**600**	**1500**	**3**	**723**
October-1	963							1373.04		
MTD Totals (wst)		24845	0	24845	1.7	25272	11500		55	11676.61
MthEnd Est (wst)		24845	0	24845	1.7	25272	11500		55	11676.61
BUDGET - (dry)				32,692			13,068			13,022.30
Variance Est vs Plan				(7847)			(1568)			(1,345.69)
Forecast										
Variance Est vs Flash				24845			11500			11677
FLASH - (dry)	957			24,681			11,031	1057.55		11,500
Variance Est vs Flash	6			164			469	315		177

Daily Comments

	Day	Date	# > 15PPM	Comments	Mudd Presses
24	Sat	1			
24	Sun	2	13, 14	C6681, CB6683	6
24	Mon	3	15, 14	C6684, C6686	4
24	Tue	4	15, 15	C6685, C6689	2
24	Wed	5	12	C6687	2
24	Thu	6	10	C6690	10
24	Fri	7	10	C6691	7
24	Sat	8	8	C6692	5
24	Sun	9	9, 10	C6693, C6694 remelted C6620 to make CC6	6
24	Mon	10	12	C6695	3
24	Tue	11			4
24	Wed	12			1
24	Thu	13	12	D6697	0
24	Fri	14	10, 7	D6700, D6699	0
24	Sat	15	10, 8, 10	D6701, C6696, D6703	5
24	Sun	16	11, 9	C6704, D6705	6
24	Mon	17	12, 8	D6706, CB6707	0
24	Tue	18	10, 13	D6708, CB6709	2
24	Wed	19	13, 14	C6710, C6711	4
24	Thu	20	11, 8, 12	C6713, D6712, D6714	4
24	Fri	21	11, 14	D6716, D6718	4
24	Sat	22	12, 8	C6717, C6721	0
24	Sun	23	13, 11	CB6720, CB6723	0
24	Mon	24	10, 11	C6719, C6722	0
24	Tue	25	7, 12	C6726, D6728	0
24	Wed	26	10, 13, 11	D6724, D6725, D6729	0
24	Thu	27	9, 12	C6730, C6731	0
24	Fri	28	8, 13, 9	D6734, C6733, D6735	0
24	Sat	29			
24	**Sun**	**30**			
			64		
720					75
					2.5
720	0.46287				

EXHIBIT B

Herculaneum Production - Consent Decree Compliance

	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	Rolling Numbers
Finished Goods Cast	13,205	12,265	6,173	10,900	14,306	4,491	11,010	13,828	12,376	9,670	6,234	434	114,892
Alloy Metal Contained	50	56	23	42	60	41	59	53	55	39	27	0	506
Other Non Lead Metals Contained	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.0	2
Refined Lead Metal Production	13,155	12,208	6,150	10,858	14,246	4,450	10,950	13,775	12,321	9,631	6,207	434	**114,385**
Consent Decree Refined Lead Metal Production Limit													**130,000.0**
Variance													15,615
Sinter Produced	30,572	27,388	10,490	25,614	32,231	8,999	29,713	27,269	28,000	26,934	6,372	665	**254,247**
Consent Decree Sinter Produced Limit													**326,370**
Variance													72,123
Sinter Consumed	30,130	28,332	11,393	25,599	31,728	8,724	29,943	26,776	27,174	27,912	7,379	-	**255,090**
Consent Decree Sinter Consumed Limit													**326,370**
Variance													71,280
Main Stack SO2	1,570	1,587	636	1,357	1,599	355	1,401	1,655	1,652	1,623	361	40	**13,837**
Consent Decree Main Stack SO2 Limit													**18,501**
Variance													4,664

Herculaneum Production - Consent Decree Compliance

	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Rolling Numbers
Finished Goods Cast	12,265	6,173	10,900	14,306	4,491	11,010	13,828	12,376	9,670	6,234	434	14,558	116,245
Alloy Metal Contained	56	23	42	60	41	59	53	55	39	27	0	50	506
Other Non Lead Metals Contained	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.2	2
Refined Lead Metal Production	12,208	6,150	10,858	14,246	4,450	10,950	13,775	12,321	9,631	6,207	434	14,507	**115,737**
Consent Decree Refined Lead Metal Production Limit													**130,000.0**
Variance													14,263
Sinter Produced	27,388	10,490	25,614	32,231	8,999	29,713	27,269	28,000	26,934	6,372	665	32,015	**255,690**
Consent Decree Sinter Produced Limit													**326,370**
Variance													70,680
Sinter Consumed	28,332	11,393	25,599	31,728	8,724	29,943	26,776	27,174	27,912	7,379	-	32,595	**257,555**
Consent Decree Sinter Consumed Limit													**326,370**
Variance													68,815
Main Stack SO2	1,587	636	1,357	1,599	355	1,401	1,655	1,652	1,623	361	40	2,016	**14,283**
Consent Decree Main Stack SO2 Limit													**18,501**
Variance													4,218

Herculaneum Production - Consent Decree Compliance

	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Rolling Numbers
Finished Goods Cast	6,173	10,900	14,306	4,491	11,010	13,828	12,376	9,670	6,234	434	14,558	13,439	117,419
Alloy Metal Contained	23	42	60	41	59	53	55	39	27	0	50	48	498
Other Non Lead Metals Contained	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.2	0.3	2
Refined Lead Metal Production	6,150	10,858	14,246	4,450	10,950	13,775	12,321	9,631	6,207	434	14,507	13,390	**116,919**
Consent Decree Refined Lead Metal Production Limit													**130,000.0**
Variance													13,081
Sinter Produced	10,490	25,614	32,231	8,999	29,713	27,269	28,000	26,934	6,372	665	32,015	30,044	**258,346**
Consent Decree Sinter Produced Limit													**326,370**
Variance													68,024
Sinter Consumed	11,393	25,599	31,728	8,724	29,943	26,776	27,174	27,912	7,379	-	32,595	30,641	**259,864**
Consent Decree Sinter Consumed Limit													**326,370**
Variance													66,506
Main Stack SO2	636	1,357	1,599	355	1,401	1,655	1,652	1,623	361	40	2,016	2,265	**14,961**
Consent Decree Main Stack SO2 Limit													**18,501**
Variance													3,540

Herculaneum Production - Consent Decree Compliance

	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Rolling Numbers
Finished Goods Cast	10,900	14,306	4,491	11,010	13,828	12,376	9,670	6,234	434	14,558	13,439	10,516	121,762
Alloy Metal Contained	42	60	41	59	53	55	39	27	0	50	48	49	523
Other Non Lead Metals Contained	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.2	0.3	0.1	2
Refined Lead Metal Production	10,858	14,246	4,450	10,950	13,775	12,321	9,631	6,207	434	14,507	13,390	10,468	**121,237**
Consent Decree Refined Lead Metal Production Limit													**130,000.0**
Variance													8,763
Sinter Produced	25,614	32,231	8,999	29,713	27,269	28,000	26,934	6,372	665	32,015	30,044	23,901	**271,757**
Consent Decree Sinter Produced Limit													**326,370**
Variance													54,613
Sinter Consumed	25,599	31,728	8,724	29,943	26,776	27,174	27,912	7,379	-	32,595	30,641	23,331	**271,802**
Consent Decree Sinter Consumed Limit													**326,370**
Variance													54,568
Main Stack SO2	1,357	1,599	355	1,401	1,655	1,652	1,623	361	40	2,016	2,265	2,087	**16,411**
Consent Decree Main Stack SO2 Limit													**18,501**
Variance													2,090

Herculaneum Production - Consent Decree Compliance

	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Rolling Numbers
Finished Goods Cast	14,306	4,491	11,010	13,828	12,376	9,670	6,234	434	14,558	13,439	10,516	15,273	126,135
Alloy Metal Contained	60	41	59	53	55	39	27	0	50	48	49	70	551
Other Non Lead Metals Contained	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.2	0.3	0.1	0.2	2
Refined Lead Metal Production	14,246	4,450	10,950	13,775	12,321	9,631	6,207	434	14,507	13,390	10,468	15,203	**125,583**
Consent Decree Refined Lead Metal Production Limit													**130,000.0**
Variance													4,417
Sinter Produced	32,231	8,999	29,713	27,269	28,000	26,934	6,372	665	32,015	30,044	23,901	32,842	**278,985**
Consent Decree Sinter Produced Limit													**326,370**
Variance													47,385
Sinter Consumed	31,728	8,724	29,943	26,776	27,174	27,912	7,379	-	32,595	30,641	23,331	33,536	**279,739**
Consent Decree Sinter Consumed Limit													**326,370**
Variance													46,631
Main Stack SO2	1,599	355	1,401	1,655	1,652	1,623	361	40	2,016	2,265	2,087	2,210	**17,264**
Consent Decree Main Stack SO2 Limit													**18,501**
Variance													1,237

Herculaneum Production - Consent Decree Compliance

	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Rolling Numbers
Finished Goods Cast	4,491	11,010	13,828	12,376	9,670	6,234	434	14,558	13,439	10,516	15,273	11,677	123,506
Alloy Metal Contained	41	59	53	55	39	27	0	50	48	49	70	56	547
Other Non Lead Metals Contained	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.2	0.3	0.1	0.2	0.2	2
Refined Lead Metal Production	4,450	10,950	13,775	12,321	9,631	6,207	434	14,507	13,390	10,468	15,203	11,620	**122,957**
Consent Decree Refined Lead Metal Production Limit													**130,000.0**
Variance													7,043
Sinter Produced	8,999	29,713	27,269	28,000	26,934	6,372	665	32,015	30,044	23,901	32,842	24,909	**271,663**
Consent Decree Sinter Produced Limit													**326,370**
Variance													54,707
Sinter Consumed	8,724	29,943	26,776	27,174	27,912	7,379	-	32,595	30,641	23,331	33,536	24,845	**272,856**
Consent Decree Sinter Consumed Limit													**326,370**
Variance													53,514
Main Stack SO2	355	1,401	1,655	1,652	1,623	361	40	2,016	2,265	2,087	2,210	1,645	**17,310**
Consent Decree Main Stack SO2 Limit													**18,501**
Variance													1,191

EXHIBIT C

EXHIBIT C

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 43
Site-Specific Underground Water Management Plan ("UWMP") Implementation Status Report
Sweetwater Mine/Mill ("Sweetwater")

Paragraph 42 of the Consent Decree required Doe Run to develop a Site-Specific Underground Water Management Plan. Paragraph 43 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 44 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific UWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific UWMP for Sweetwater on November 7, 2011. This Status Report provides a summary of the actions conducted pursuant to the Sweetwater UWMP for the Semi-Annual Report period of April 2012 through September 2012 as well as any modifications made to the Sweetwater UWMP.

Training. Initial training, including education of key mine personnel, as to the various elements of the UWMP, was initiated during the development of the UWMP. Further detailed training for key mine and environmental personnel was completed on April 18, 2012. In addition, Doe Run's Environmental Technicians received additional training on April 4, 2012 as to the UWMP to assist with ongoing on-site training and questions regarding UWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise. Annual refresher training for UWMPs will be conducted within one year of the initial training.

Inspections. Previously the UWMP indicated that general and sump inspections should occur quarterly by trained personnel. Doe Run is currently transitioning to calendar quarters for conducting inspections. Doe Run conducted UWMP inspections, including the sumps, on April 30, 2012 and July 30, 2012. The Inspection Form, contained in Appendix D of the UWMP was utilized and will be kept in a file on-site. In addition to formal, quarterly inspections, Doe Run conducts periodic informal inspections as part of its operations.

Sampling. The UWMP suggests sampling at locations specified in the plan for six months after submission of the UWMP. Doe Run has conducted underground sampling at Sweetwater once monthly from January to September 2012. After the first six months of data was collected, evaluation of the data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

CDH7 Flow Reduction Test.

The UWMP discusses alternatives for reducing flow from the CDH7 area. The previous version of the UWMP discussed a pumping test that would be used to observe the effect of the groundwater withdrawal on the flow from CDH7 and would have involved the installation of an extraction well and pump system, operation of the pump, and data collection. After further review of historical documents, Doe Run discovered that this option had already been explored and was deemed not feasible due to the amount of water that would need to be pumped. Doe Run is continuing to evaluate means of reducing flow from CDH7. In August 2012, Doe Run began a grout feasibility analysis in lieu of the pumping test described above. This analysis included drilling a series of test holes to observe the conditions in the immediate area of the shaft to determine if chemical grout could be used to block the inflow of the water into the water conduit of the shaft. After completion of this analysis, Doe Run determined that the chemical grouting is not the best option for reducing flow at this time. Other potentially effective alternatives for eliminating flow from CDH7 are currently being explored.

Piping. Underground at Sweetwater, water flows from CDH7 to #5 Sump to A-Area Sump. Piping from #5 Sump to A-Area Sump was scheduled to be completed by June 2012 and was completed ahead of schedule. The UWMP discusses installation of piping from vent shaft CDH7 to Sump 5 by November 2012. This project is contingent upon the completion of the CDH7 flow reduction project. Mine water also flows from the West mine to the #2 Sump. Piping from the West mine commenced April 15, 2012 and should be completed within six months.

Corehole Sealing. The UWMP sets forth a process for corehole discovery and sealing, which formalized existing Doe Run procedures for corehole discovery, evaluation and sealing. No coreholes were identified since submission of the UWMP through the relevant timeframe of this Report.

Ongoing Water Management Measure Evaluations. The UWMP indicates that Doe Run will continue to evaluate and implement water management measures at Sweetwater. Other than the site-specific projects discussed herein, Doe Run did not begin additional measures during the relevant timeframe.

Best Management Practices. Doe Run is implementing Best Management Practices ("BMPs"), where applicable, underground at Sweetwater as described in the UWMP. In addition to the BMPs described in the UWMP, Doe Run removed excess sediment from cell 3 at #5 Sump and the #5 Sump ditch in April 2012, and from the M Block Sump in August 2012. Doe Run also installed a pump in the #2 Sump to pump water from #2 Sump to A-Area in September 2012. Previously, mine water was pumped to surface from #2 Sump and A-Area Sump. With the installation of the new pump, mine water is now only pumped from A-Area Sump. A-Area Sump has greater storage capacity and allows mine water pumped from #2 Sump to have more settling time before it is pumped to surface.

Recordkeeping. Doe Run has incorporated tasks described in the Sweetwater UWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run has also hired additional personnel to assist with the environmental task management system and completion of environmental implementation schedule deadlines. Doe Run keeps records discussed in the UWMP on-site.

Plan Review and Update. Modifications to the UWMP have been noted in this Report. Progress reports will be provided as required by Paragraph 43 of the Consent Decree.

EXHIBIT D

EXHIBIT D

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 43
Site-Specific Underground Water Management Plan ("UWMP") Implementation Status Report
Viburnum #29 Mine ("Viburnum")

Paragraph 42 of the Consent Decree required Doe Run to develop a Site-Specific Underground Water Management Plan. Paragraph 43 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 44 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific UWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific UWMP for Viburnum on December 2, 2011. This Status Report provides a summary of the actions conducted pursuant to the Viburnum UWMP for the Semi-Annual Report period of April 2012 through September 2012 as well as any modifications made to the Viburnum UWMP.

Training. Initial training, including education of key mine personnel, as to the various elements of the UWMP, was initiated during the development of the UWMP. In addition, Doe Run's Environmental Technicians received additional training on April 4, 2012 as to the UWMP to assist with ongoing on-site training and questions regarding UWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise. Annual refresher training for UWMPs will be conducted within one year of the initial training.

Inspections. Previously the UWMP indicates that general and sump inspections should occur quarterly by trained personnel, Doe Run is currently transitioning to calendar quarters for conducting inspections. Inspections were conducted June 7, 2012 and September 20, 2012. The Inspection Form, contained in Appendix D of the UWMP was utilized and will be kept in a file on-site. In addition to formal, quarterly inspections, Doe Run conducts periodic informal inspections as part of its operations.

Sampling. The UWMP suggests sampling at locations specified in the plan for six months after submission of the UWMP. Doe Run has conducted underground sampling at Viburnum once monthly from January to September 2012. After the first six months of data was collected, evaluation of the data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

Piping. No piping projects were indicated in the UWMP for the Viburnum Mine. As such, no piping projects are currently scheduled at Viburnum. Doe Run will evaluate whether piping should be installed on an as-needed basis.

Corehole Sealing. The UWMP sets forth a process for corehole discovery and sealing, which formalized existing Doe Run procedures for corehole discovery, evaluation and sealing. No coreholes were identified since submission of the UWMP through the relevant timeframe of this Report.

Road Rock Hole Flow Reduction. The UWMP discusses the road rock hole. This area was estimated as the source of approximately one-third of the water entering the mine (200 gallons per minute). The UWMP indicates that Doe Run will investigate the technical feasibility and the cost of sealing the road rock hole by December 2012. Doe Run completed the sealing of the road rock hole in September 2012 with nine yards of concrete. Currently, the seal shows no signs of failure and will continue to be monitored for leaks.

Ongoing Water Management Measure Evaluations. The UWMP indicates that Doe Run will continue to evaluate and implement water management measures at Viburnum. Other than site-specific projects discussed herein, Doe Run did not begin additional measures during the relevant timeframe.

Best Management Practices. Doe Run is implementing Best Management Practices ("BMPs"), where applicable, underground at Viburnum as described in the UWMP. In addition to the BMPs described in the UWMP, Doe Run removed excess sediment from several small satellite sumps in April and May 2012. Doe Run also added a new road pipe in area 89V27 to minimize water flowing on the road and performed routine maintenance of roadways by adding rock to raise the roadway level to ensure water stays flowing in the ditches.

Recordkeeping. Doe Run has incorporated tasks described in the Viburnum UWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run has also hired additional personnel to assist with the environmental task management system and completion of environmental implementation schedule deadlines. Doe Run keeps records discussed in the UWMP on-site.

Plan Review and Update. Modifications to the UWMP have been noted in this Report. Progress reports will be provided as required by Paragraph 43 of the Consent Decree.

EXHIBIT E

EXHIBIT E

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 43
Site-Specific Underground Water Management Plan ("UWMP") Implementation Status Report
Viburnum Mine #35 ("Casteel")

Paragraph 42 of the Consent Decree required Doe Run to develop a Site-Specific Underground Water Management Plan. Paragraph 43 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 44 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific UWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific UWMP for Casteel on January 10, 2012. This Status Report provides a summary of the actions conducted pursuant to the Casteel UWMP for the Semi-Annual Report period of April 2012 through September 2012 as well as any modifications made to the Casteel UWMP.

Training. Initial training, including education of key mine personnel, as to the various elements of the UWMP, was initiated during the development of the UWMP. In addition, Doe Run's Environmental Technicians received additional training on April 4, 2012 as to the UWMP to assist with ongoing on-site training and questions regarding UWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise. Annual refresher training for UWMPs will be conducted within one year of the initial training.

Inspections. Previously the UWMP indicated that general and sump inspections should occur quarterly by trained personnel. Inspections were conducted April 27, 2012 and July 30, 2012. Doe Run is currently transitioning to calendar quarters for conducting inspections. The Inspection Form, contained in Appendix D of the UWMP was utilized and will be kept in a file on-site. In addition to formal, quarterly inspections, Doe Run conducts periodic informal inspections as part of its operations.

Sampling. The UWMP suggests sampling at locations specified in the plan for six months after submission of the UWMP. Doe Run has conducted underground sampling at Casteel once monthly from January to September 2012. After the first six months of data was collected, evaluation of the data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

Piping. The UWMP discusses installation of piping in 30BJC and 86 Sump. These piping projects were completed by June 2012. The UWMP also discusses ongoing piping evaluations. On an as-needed basis, Doe Run will continue to evaluate whether piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation.

Corehole Sealing. The UWMP sets forth a process for corehole discovery and sealing, which formalized existing Doe Run procedures for corehole discovery, evaluation and sealing. No coreholes were identified since submission of the UWMP through the relevant timeframe of this Report.

Ongoing Water Management Measure Evaluations. The UWMP indicates that Doe Run will continue to evaluate and implement water management measures at Casteel. Other than site-specific projects discussed herein, Doe Run did not begin additional measures during the relevant timeframe.

Best Management Practices. Doe Run is implementing Best Management Practices ("BMPs"), where applicable, underground at Casteel as described in the UWMP. In addition to the BMPs described in the UWMP, Doe Run added a new road pipe in areas 65W30 and 09V13, and in the south mine road to minimize water flowing on the road and performed routine maintenance of roadways to minimize water flowing in the roadway.

Recordkeeping. Doe Run has incorporated tasks described in the Casteel UWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run has also hired additional personnel to assist with the environmental task management system and completion of environmental implementation schedule deadlines. Doe Run keeps records discussed in the UWMP on-site.

Plan Review and Update. Modifications to the UWMP have been noted in this Report. Progress reports will be provided as required by Paragraph 43 of the Consent Decree.

EXHIBIT F

EXHIBIT F

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 43
Site-Specific Underground Water Management Plan ("UWMP") Implementation Status Report
Buick Mine/Mill ("Buick")

Paragraph 42 of the Consent Decree required Doe Run to develop a Site-Specific Underground Water Management Plan. Paragraph 43 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 44 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific UWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific UWMP for Buick on January 30, 2012. This Status Report provides a summary of the actions conducted pursuant to the Buick UWMP for the Semi-Annual Report period of April 2012 through September 2012 as well as any modifications made to the Buick UWMP.

Training. Initial training, including education of key mine personnel, as to the various elements of the UWMP, was initiated during the development of the UWMP. Further detailed training for key mine and environmental personnel was completed on April 18, 2012. In addition, Doe Run's Environmental Technicians received additional training as to the UWMP to assist with ongoing on-site training and questions regarding UWMP implementation April 4, 2012. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise. Annual refresher training for UWMPs will be conducted within one year of the initial training.

Inspections. Previously the UWMP indicates that general and sump inspections should occur quarterly by trained personnel. Doe Run is currently transitioning to calendar quarters for conducting inspections. Inspections were conducted in April, May, June, July, August, and September 2012. The Inspection Form, contained in Appendix D of the UWMP was utilized and will be kept in a file on-site. In addition to formal, quarterly inspections, Doe Run conducts periodic informal inspections as part of its operations.

Sampling. The UWMP suggests sampling at locations specified in the plan for six months after submission of the UWMP. Doe Run has conducted underground sampling at Buick once monthly from February to September 2012. After the first six months of data was collected, evaluation of the data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

Piping. No piping projects were indicated in the UWMP for the Buick Mine. As such, no piping projects are currently scheduled at Buick. Doe Run will evaluate whether piping should be installed on an as-needed basis.

Corehole Sealing. The UWMP sets forth a process for corehole discovery and sealing, which formalized existing Doe Run procedures for corehole discovery, evaluation and sealing. No coreholes were identified since submission of the UWMP through the relevant timeframe of this Report. Doe Run will continue to follow the procedures outlined in the UWMP.

Ongoing Water Management Measure Evaluations. The UWMP indicates that Doe Run will continue to evaluate and implement water management measures at Buick. Other than site-specific projects discussed herein, Doe Run did not begin additional measures during the relevant timeframe.

Best Management Practices. Doe Run is implementing Best Management Practices ("BMPs"), where applicable, underground at Buick as described in the UWMP. In addition to the BMPs described in the UWMP, Doe Run added a new road pipe in the 142N bypass road to eliminate water flowing in the road and built a bridge at Thompson undercut to allow water to flow under the roadway reducing tracking of sediment into the water. Doe Run also installed a valve at 1-5 North Dam to regulate the sump level to allow water to remain in sumps longer and settle more before the water is discharged to surface. Routine maintenance to ditches, including sediment removal, was conducted from May through September 2012 throughout the mine to reduce metal loading to water before it enters the sumps.

Recordkeeping. Doe Run has incorporated tasks described in the Buick UWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run has also hired additional personnel to assist with the environmental task management system and completion of environmental implementation schedule deadlines. Doe Run keeps records discussed in the UWMP on-site.

Plan Review and Update. Modifications to the UWMP have been noted in this Report. Progress reports will be provided as required by Paragraph 43 of the Consent Decree.

EXHIBIT G

EXHIBIT G

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 43
Site-Specific Underground Water Management Plan ("UWMP") Implementation Status Report
Brushy Creek Mine/Mill ("Brushy Creek")

Paragraph 42 of the Consent Decree required Doe Run to develop a Site-Specific Underground Water Management Plan. Paragraph 43 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 44 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific UWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific UWMP for Brushy Creek on March 1, 2012. This Status Report provides a summary of the actions conducted pursuant to the Brushy Creek UWMP for the Semi-Annual Report period of April 2012 through September 2012 as well as any modifications made to the Brushy Creek UWMP.

Training. Initial training, including education of key mine personnel, as to the various elements of the UWMP, was initiated during the development of the UWMP. Further detailed training for key mine and environmental personnel was completed on April 13, 2012. In addition, Doe Run's Environmental Technicians received additional training on April 4, 2012 as to the UWMP to assist with ongoing on-site training and questions regarding UWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise. Annual refresher training for UWMPs will be conducted within one year of the initial training.

Inspections. Previously the UWMP indicated that general and sump inspections should occur quarterly by trained personnel. Doe Run is currently transitioning to calendar quarters for conducting inspections. Inspections were conducted April 30, 2012 and August 17, 2012. The Inspection Form, contained in Appendix D of the UWMP was utilized and will be kept in a file on-site. In addition to formal, quarterly inspections, Doe Run conducts periodic informal inspections as part of its operations.

Sampling. The UWMP suggests sampling at locations specified in the plan for six months after submission of the UWMP. Doe Run has conducted underground sampling at Brushy Creek once monthly from April to September 2012. After the first six months of data was collected, evaluation of the data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

Piping. The UWMP discusses installation of piping from the 9UC discharge location to the south mine sump. Doe Run expects to complete the project by the end of the 2012 unless unforeseen complications arise. The UWMP also discusses ongoing piping evaluations. On an as-needed basis, Doe Run will continue to evaluate whether piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation.

Corehole Sealing. The UWMP sets forth a process for corehole discovery and sealing, which formalized existing Doe Run procedures for corehole discovery, evaluation and sealing. No coreholes were identified since submission of the UWMP through the relevant timeframe of this Report.

Best Management Practices. Doe Run is implementing Best Management Practices ("BMPs"), where applicable, underground at Brushy Creek as described in the UWMP. In addition to the BMPs described in the UWMP, Doe Run removed excess sediment from the south sump in July 2012 and from 69 sump and the north sump in August 2012. Doe Run also installed two road pipes at B14 Roadway to minimize water flowing in the roadway.

Recordkeeping. Doe Run has incorporated tasks described in the Brushy Creek UWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run has also hired additional personnel to assist with the environmental task management system and completion of environmental implementation schedule deadlines. Doe Run keeps records discussed in the UWMP on-site.

Plan Review and Update. Modifications to the UWMP have been noted in this Report. Progress reports will be provided as required by Paragraph 43 of the Consent Decree.

EXHIBIT H

EXHIBIT H

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 43
Site-Specific Underground Water Management Plan ("UWMP") Implementation Status Report
Fletcher/West Fork Mine ("Fletcher")

Paragraph 42 of the Consent Decree required Doe Run to develop a Site-Specific Underground Water Management Plan. Paragraph 43 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 44 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific UWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific UWMP for Fletcher on April 2, 2012. This Status Report provides a summary of the actions conducted pursuant to the Fletcher UWMP for the Semi-Annual Report period of April 2012 through September 2012 as well as any modifications made to the Fletcher UWMP.

Training. Initial training, including education of key mine personnel, as to the various elements of the UWMP, was initiated during the development of the UWMP. Further detailed training for key mine and environmental personnel was completed on April 26, 2012. In addition, Doe Run's Environmental Technicians received additional training on April 4, 2012 as to the UWMP to assist with ongoing on-site training and questions regarding UWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise. Annual refresher training for UWMPs will be conducted within one year of the initial training.

Inspections. Previously, the UWMP indicated that general and sump inspections should occur quarterly by trained personnel. Doe Run is currently transitioning to calendar quarters for conducting inspections. Doe Run conducted UWMP inspections including the sumps on May 29, 2012 and September 25, 2012. The Inspection Form, contained in Appendix D of the UWMP was utilized and will be kept in a file on-site. In addition to formal, quarterly inspections, Doe Run conducts periodic informal inspections as part of its operations.

Sampling. The UWMP suggests sampling at locations specified in the plan for six months after submission of the UWMP. Doe Run has conducted underground sampling at Fletcher once monthly from April to September 2012. The first six months of data collected will be evaluated when the final results are received to determine if adequate data has been collected to provide a more thorough different understanding of water quality. Based on that evaluation, sampling may continue, be reduced from monthly to quarterly, or be discontinued.

Piping. No piping projects were indicated in the UWMP for the Fletcher Mine. Doe Run is planning to pipe water from the southwest development area back to the southwest sump in RCWF. Doe Run will also continue to evaluate whether piping should be installed on an as-needed basis.

<u>Corehole Sealing</u>. The UWMP sets forth a process for corehole discovery and sealing, which formalized existing Doe Run procedures for corehole discovery, evaluation and sealing. No coreholes were identified since submission of the UWMP through the relevant timeframe of this Report.

<u>Old Powerline Hole Project</u>. The UWMP discusses sealing the Old Powerline Hole. This project is scheduled to be completed by March 2013. Doe Run is currently in the evaluations stage of this project.

<u>Ongoing Water Management Measure Evaluations</u>. The UWMP indicates that Doe Run will continue to evaluate and implement water management measures at Fletcher. Other than site-specific projects discussed herein, Doe Run did not begin additional measures during the relevant timeframe.

<u>Best Management Practices</u>. Doe Run is implementing Best Management Practices ("BMPs"), where applicable, underground at Fletcher as described in the UWMP. In addition to the BMPs described in the UWMP, Doe Run removed excess sediment from the south sump in June 2012. Doe Run also built up the south main haul road to prevent haulage traffic from driving through water.

<u>Recordkeeping</u>. Doe Run has incorporated tasks described in the Fletcher UWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run has also hired additional personnel to assist with the environmental task management system and completion of environmental implementation schedule deadlines. Doe Run keeps records discussed in the UWMP on-site.

<u>Plan Review and Update</u>. Modifications to the UWMP have been noted in this Report. Progress reports will be provided as required by Paragraph 43 of the Consent Decree.

EXHIBIT I

UNDERGROUND WATER MANAGEMENT PLAN for the SWEETWATER MINE and MILL

Prepared for: **The Doe Run Resources Corporation d/b/a The Doe Run Company**

November 7, 2011

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1. INTRODUCTION

This document presents the Underground Water Management Plan (UGWMP) for the Sweetwater Mine and Mill, prepared on behalf of the Doe Run Resources Corporation, d/b/a/ The Doe Run Company (Doe Run). The Sweetwater UGWMP has been prepared in accordance with the Master UGWMP previously prepared by Resource Environmental Management Consultants, Inc. In keeping with the Master UGWMP, this plan presents an evaluation of the technical & economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Sweetwater Mine and Mill is located in Reynolds County, Missouri, approximately 26 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Sweetwater Mine and Mill (USGS, 2008).

Year	Event
1962	Discovery borehole drilled by Bear Creek Mining Company, an exploration subsidiary of Kennecott Copper
1968	Production began under the name Ozark Lead Company Mine
1983	Production suspended by Ozark Lead Company Mine
1986	Mine purchased by Asarco, Inc. and renamed Sweetwater Mine
1987	Production resumed
1997	Mine purchased by Doe Run

The Sweetwater Mine and Mill is the southernmost mine in the Viburnum Trend. Mining operations occur approximately 1400 feet below ground surface.

1.2 OBJECTIVES

As stated above, the main objective of this UGWMP is to evaluate the technical & economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility. This main objective is met through the following:

- Understanding of the sources, quantity and movement of water through the mine.
- Understanding of the quality of water entering, moving through, and leaving the mine, with respect to the target constituents of interest.

- Identification and evaluation of potential control measures for reducing water volumes, metals concentrations, or both in the mine.

Each of these items is discussed in this plan. The UGWMP also presents an assessment of the technical feasibility of various potential control measures for the Sweetwater Mine and Mill, as well as a plan for further investigation or implementation of potentially technical feasible control measures, based on whether such measures are likely to reduce metals loading and whether they are cost-effective.

1.3 UNDERGROUND WATER MANAGEMENT TEAM

Underground water management for the Sweetwater Mine and Mill will be the responsibility of the individuals named in Table 1-2.

Table 1-2. Sweetwater Mine and Mill Underground Water Management Team.

Job Title	Name	Contact Information	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	P.O. Box 500 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mine Manager	Greg Sutton	P.O. Box 500 Viburnum, MO 65566 573-626-2001	Oversight and management of Doe Run Mining Operations
Sweetwater – General Mine Supervisor	Shawn Pratt	1382 Sweetwater Mine Rd Ellington, MO 63638 573-924-2222 ext. 2421	Sweetwater UGWMP Primary Oversight, Implementation, and Record-Keeping
Sweetwater Mine Superintendent	Ray Morgan	1382 Sweetwater Mine Rd Ellington, MO 63638 573-924-2222 ext. 2454	Sweetwater UGWMP Secondary Oversight, Implementation, and Record-Keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573-689-4535	Environmental data collection, management, and reporting

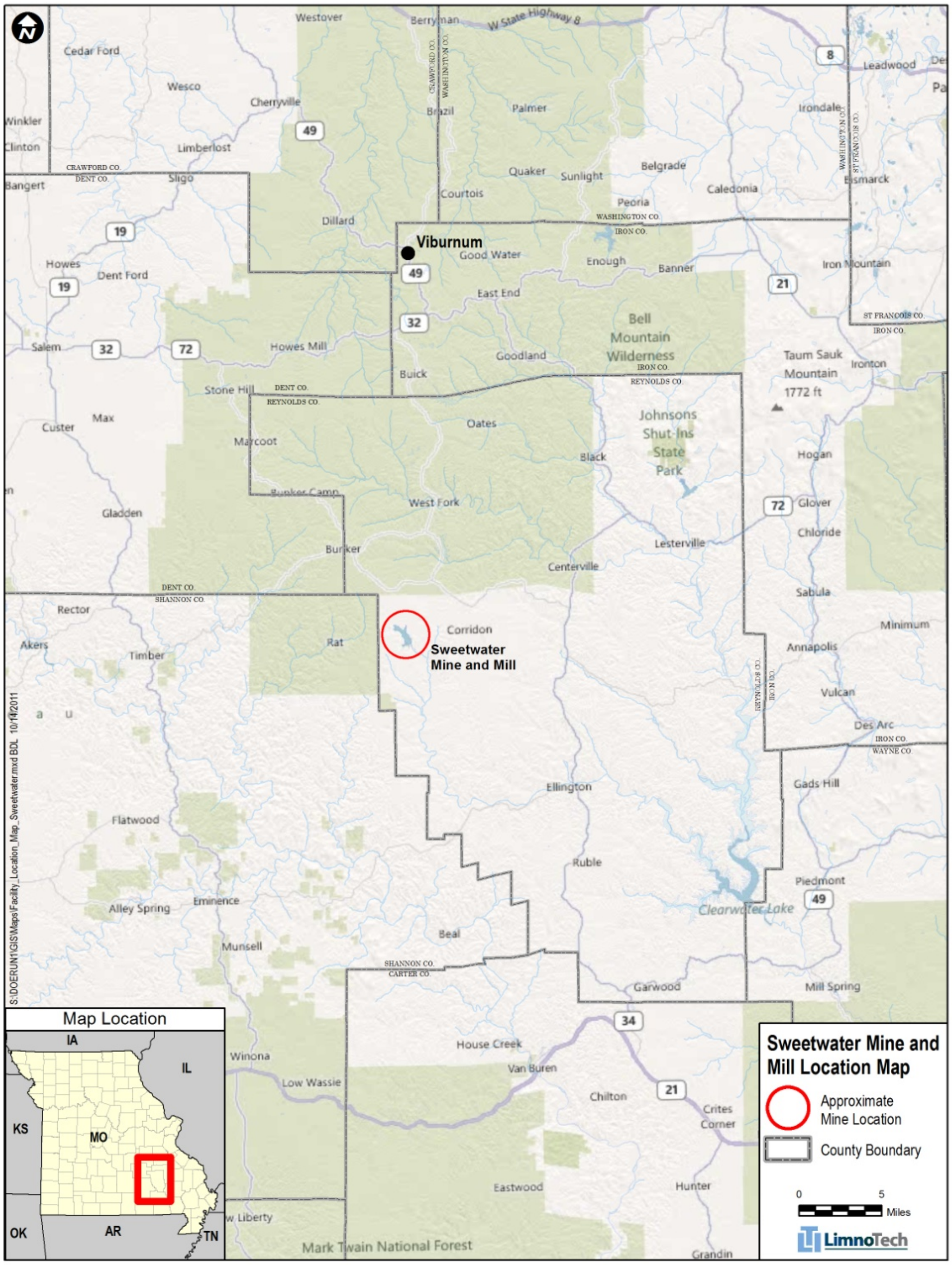


Figure 1-1. Location of the Sweetwater Mine and Mill.

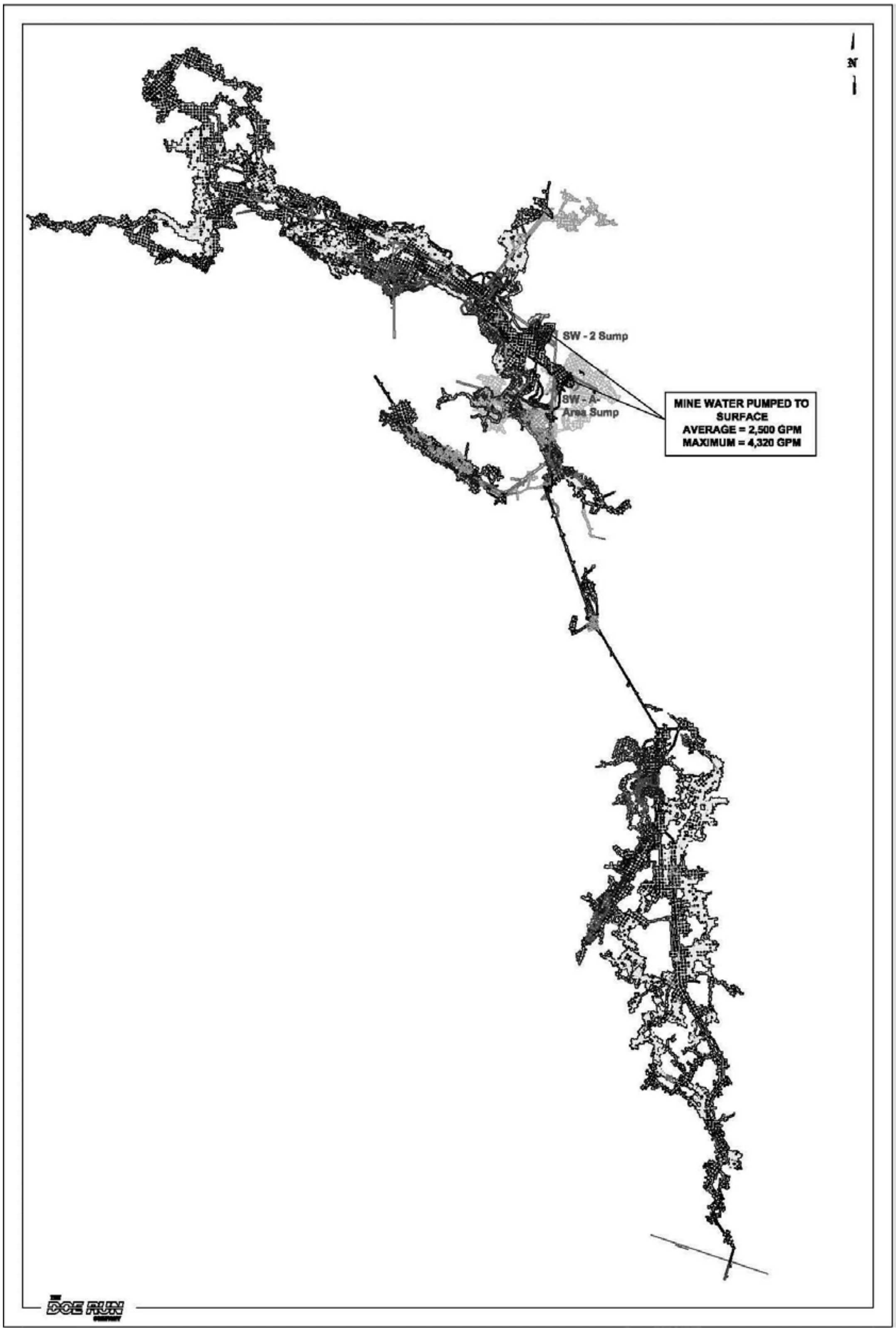


Figure 1-2. Layout of the Sweetwater Mine.

2. SUMMARY OF MINE WATER DATA

The Master UGWMP outlined the hierarchy of water management priorities listed below from highest priority to lowest.

1. Source Control
2. Water Minimization
3. Reuse or Reclamation
4. Water Treatment
5. Discharge

Because source control has been identified as the first water management priority, source identification is a fundamental part of the planning effort for potential measures to control metals loading. Load is a function of both flow and concentration; therefore, these components were each examined independently at the Sweetwater Mine and Mill, as described below.

2.1 WATER SOURCES AND MOVEMENT

An inventory of water in the Sweetwater Mine was compiled for this plan based on the best available information and includes the following components:

- Total mine water flows
- Sources of mine water
- Current underground management of mine water

Each of these components is described below.

2.1.1 Total Mine Water Flows

Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Sweetwater Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-1.

Table 2-1. Mine Water Flowrates Pumped to Surface at Sweetwater Mine.

Quantity	**Value**
Average Flow Pumped to Surface	2,500 gpm
Maximum Design Flow Pumped to Surface	4,320 gpm

Flow data are not currently recorded but flow is metered and instantaneous flow measurements can be read from the meter. It is known that flow rate can vary over time depending on factors such as season or where the mine is being advanced, however the values in Table 2-1 represent the best available estimate.

2.1.2 Sources of Mine Water

Water enters the Sweetwater Mine through open (unsealed) coreholes, shafts, and general seepage. Given the diffuse nature of water entering the mine it is difficult, if not impossible, to accurately measure all sources. In general, the best approach is to start with the total flow and work towards allocating that flow to different sources. At the Sweetwater Mine, the major flow distribution is as follows:

- Approximately 300 – 500 gpm of the total flow to the central mine water sumps (#2 sump and A-area sump) comes from the part of the mine northwest of the sumps.
- The remaining 2,000 – 2,200 gpm of average mine water flows come from the south end of the mine.
- Of the mine water coming from the south end of the mine, an estimated 1,000 gpm comes from ventilation shaft CDH7. This single source accounts for approximately 40% of all mine water entering Sweetwater Mine, on average.

This flow distribution is depicted schematically in Figure 2-1.

CDH7 is not an exploratory corehole, but a ventilation shaft for the mine, eight feet in diameter. It was originally built with a steel casing, but the casing ruptured (ca. 2005), at a depth of approximately 500 feet below the surface. This rupture allowed the entry of water from the surrounding aquifer, resulting in the high flows experienced today. Two obstacles prevent sealing of the rupture: first, the high rate of flowing water prevents the adequate placement of grout; and second, the surrounding aquifer is karst limestone, with not just fractures, but caverns that would need to be filled with grout.

Aside from CDH7, there are several coreholes that may allow water to enter the mine, which contribute to the flows in the first two bullets listed above. Personnel at Sweetwater Mine have catalogued coreholes with measurable flow and the information is presented in Table 2-2.

Table 2-2. Flowing Coreholes at Sweetwater Mine.

Corehole	Estimated Flow (gpm)
7 GI Corehole #42-370 (Back)	3
7 GI Corehole (Back)	6 – 8
Suf. Hole Main Drift 5 Pump (Back)	0.5
5-Dump Corehole #42-360 (Wall)	1.5
5-Dump Corehole #42-364 (Wall)	1
J-22 Corehole (Back)	3
J-22 Corehole (Wall)	7 – 9
J-21-Surf Hole (Back)	8 – 10
985-1 SW Drift (Back)	2
SDVLD – South (Back)	12
M2 Hole	50 – 55
Pillar at F8	5

The total estimated flow from these coreholes is 99 to 110 gpm, which is very small compared to the flow from CDH7. There may be other coreholes at Sweetwater, but they do not contribute measurable flow at this time.

Other sources of water to the Sweetwater Mine include general seepage from fractures in the back and walls of the mine and open stopes, as well as seepage from vent shafts. These other sources are diffuse and not easily quantified.

2.1.3 Current Underground Water Management Practices

Current practices to manage mine water at Sweetwater Mine are primarily focused on maintaining safe and workable conditions in the mine and are not specifically designed to maintain or improve water quality. These practices include the following:

- Corehole plugging –Plugging of coreholes that contribute significant flows, where feasible, has historically been performed at Sweetwater. Corehole plugging is discussed in greater detail in Section 3.1.1.
- Piping – Piping of water through the mine has historically been performed to facilitate transfer pumping from one location to another, where mine grades prevent gravity flow. Piping is discussed in greater detail in Section 3.2.2.
- Sump cleaning – Sump cleaning, or mucking as it is called by mine personnel, has historically been performed as needed to maintain performance of the

mine water sump pumps. Sump mucking is discussed in greater detail in Section 3.2.4.

Although it may not be their specific intent, these practices may have an incidental benefit of protecting water quality. These and other potential water management practices to preserve or improve water quality are discussed in greater detail in Section 3 of this Plan.

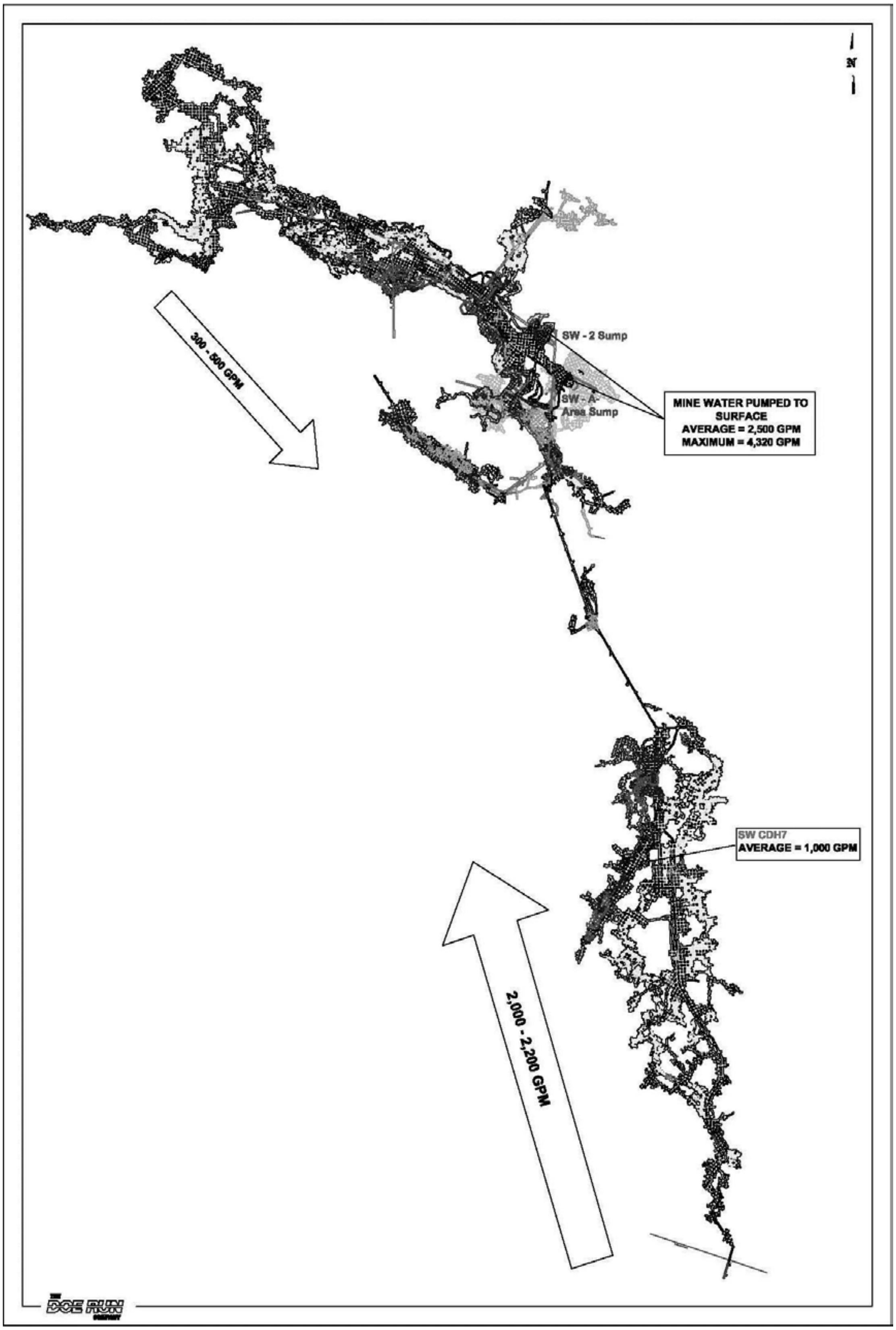


Figure 2-1. Major Mine Water Flows for the Sweetwater Mine.

2.2 MINE WATER QUALITY

To support development of this and other water management plans at Doe Run mine/mill facilities, a water quality sampling program was implemented between December 2010 and June 2011. Three rounds of underground water sampling were performed at each mine. The details of the underground sampling program, including the sampling results, are presented in the Underground Water Sampling and Analysis Plan Report (LimnoTech, August 4, 2011). A map of Sweetwater Mine showing sample locations, water flow paths, pump information, and sampling results for total and dissolved lead and zinc, is included as Appendix A.

These data were evaluated to better understand mine water quality at Sweetwater Mine and to discern factors that may improve or degrade mine water quality. Because the purpose of this UGWMP and the surface water management plan at Sweetwater is to be part of a comprehensive effort above and below ground to attain compliance with Missouri State Operating Permit (MSOP) limits for the discharge of mine water and other sources to waters of the State, the mine water data were evaluated in reference to the final discharge limits in the MSOP for the Sweetwater Mine and Mill. The final limits for the primary constituents of interest are summarized in Table 2-3 below.

Table 2-3. Final MSOP Limits for the Sweetwater Mine/Mill Facility.

Parameter	**Final Effluent Limits**	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	0.9	0.5
Copper, total recoverable	44.5	14.8
Lead, total recoverable	30.4	10.3
Zinc, total recoverable	271.2	96.1

The findings of this evaluation are presented in the following sections.

2.2.1 Incoming Mine Water Quality

Incoming mine water quality at Sweetwater is characterized by samples collected at location CDH7, which is an eight-foot diameter ventilation shaft in the south branch of the mine. Three samples were collected from this location during the underground water sampling program and the data are presented in Table 2-4.

Table 2-4. Incoming Mine Water Quality at Sweetwater Mine.

Sampling Date	**Parameter**			
	Total Cadmium (μg/L)	Total Copper (μg/L)	Total Lead (μg/L)	Total Zinc (μg/L)
2-24-11	ND (0.08)	ND (0.5)[1]	0.23	1.4
3-31-11	ND (0.08)	ND (0.5)	0.31	1.8
5-25-11	0.12	ND (0.5)	0.61	0

Comparing these results to the final discharge limits presented in Table 2-3 shows that concentrations of primary metals in incoming mine water are well below the final permitted discharge limits. It should be noted that, although incoming mine water is represented here by samples collected only at CDH7, it is expected that incoming mine water at other locations has similar quality.

2.2.2 Comparison of Incoming and Outgoing Mine Water

Inspection of the water data collected throughout Sweetwater Mine shows that samples at many locations contain concentrations of target metals above the final permitted effluent limits, so incoming and outgoing mine water (i.e., mine water pumped to the surface) were compared to discern which of those metals exceed their respective final discharge limits. These comparisons of samples taken of incoming mine water at CDH7 and mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-2, 2-3, 2-4, and 2-5, respectively.

As stated above, incoming mine water quality is characterized by samples collected at CDH7. Outgoing mine water is characterized by samples collected at #2 Sump, sample locations SW-2 Sump SI and SW-2 Sump WI, and A-Area Sump, sample location A Sump Inf. A total of six samples were collected at these sump locations in the initial sampling program and an additional eight samples were collected from January to August 2012.

The comparison of incoming and outgoing mine water shows that incoming mine water, at least in the samples collected at CDH7, is not expected to exceed the final effluent limits for lead, zinc, cadmium, or copper. Mine water pumped to the surface, however, does exceed these final limits. This indicates that metals concentrations in mine water increase as the water is exposed to the mine workings. The relationship

[1] ND indicates that the parameter was not detected at the analytical detection limit shown in parentheses.

between increased metals concentrations and increased suspended solids in mine water is discussed in Section 2.2.4 of this plan.

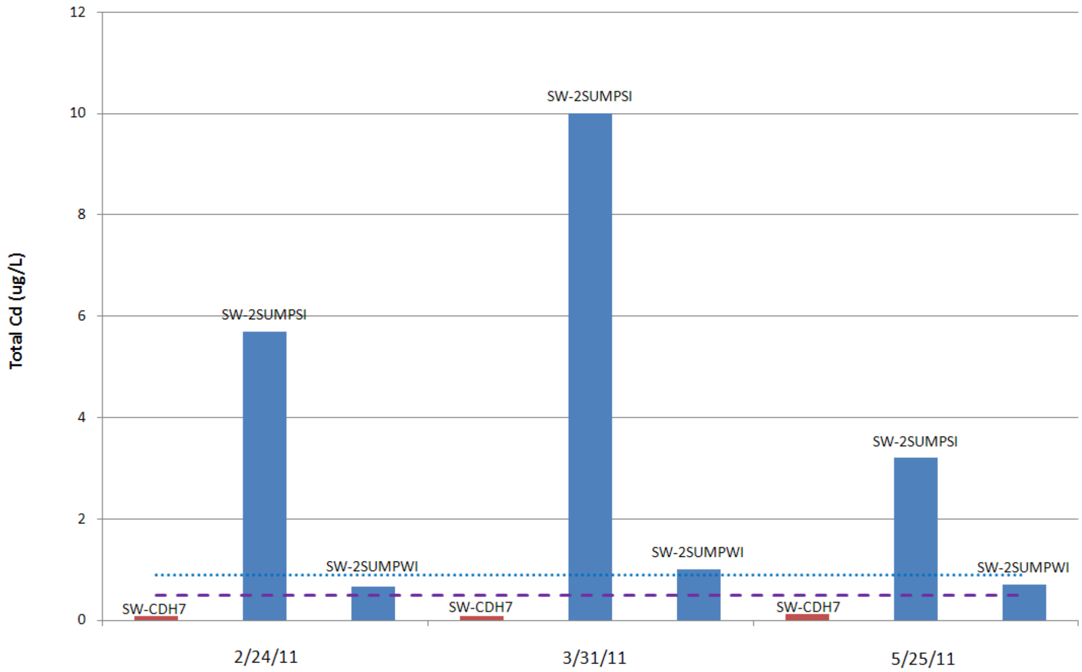


Figure 2-2. Incoming (sample location CDH7) vs. Outgoing (sample location SW-2-Sump) Mine Water Quality at Sweetwater Mine: Total Cadmium.

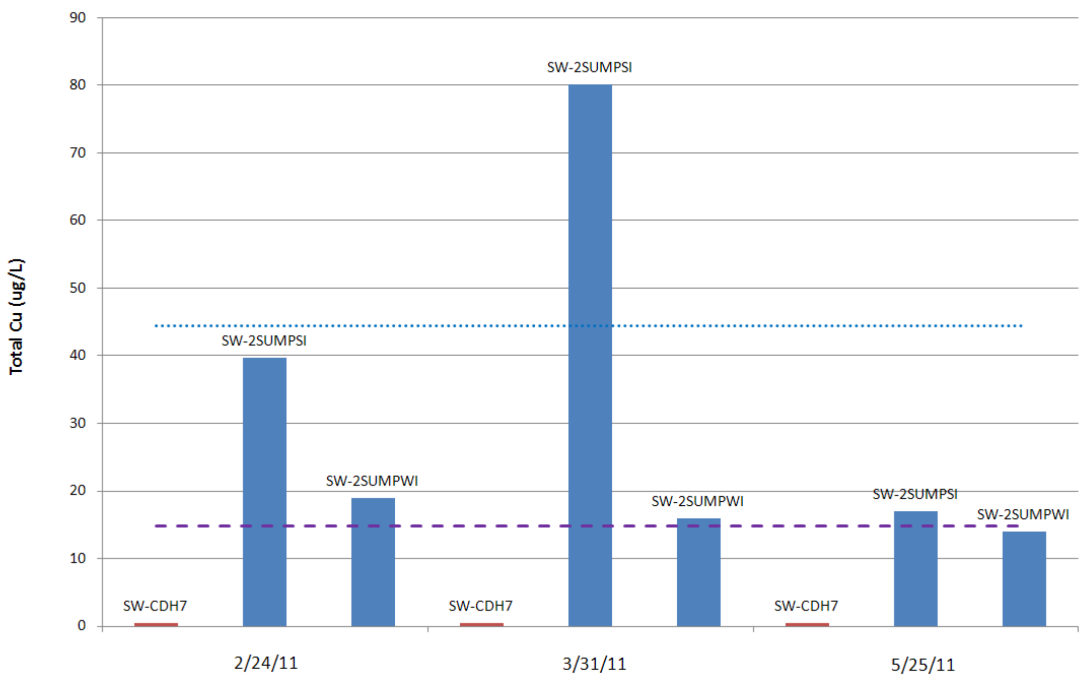


Figure 2-3. Incoming (sample location CDH7) vs. Outgoing (sample location SW-2-Sump) Mine Water Quality at Sweetwater Mine: Total Copper.

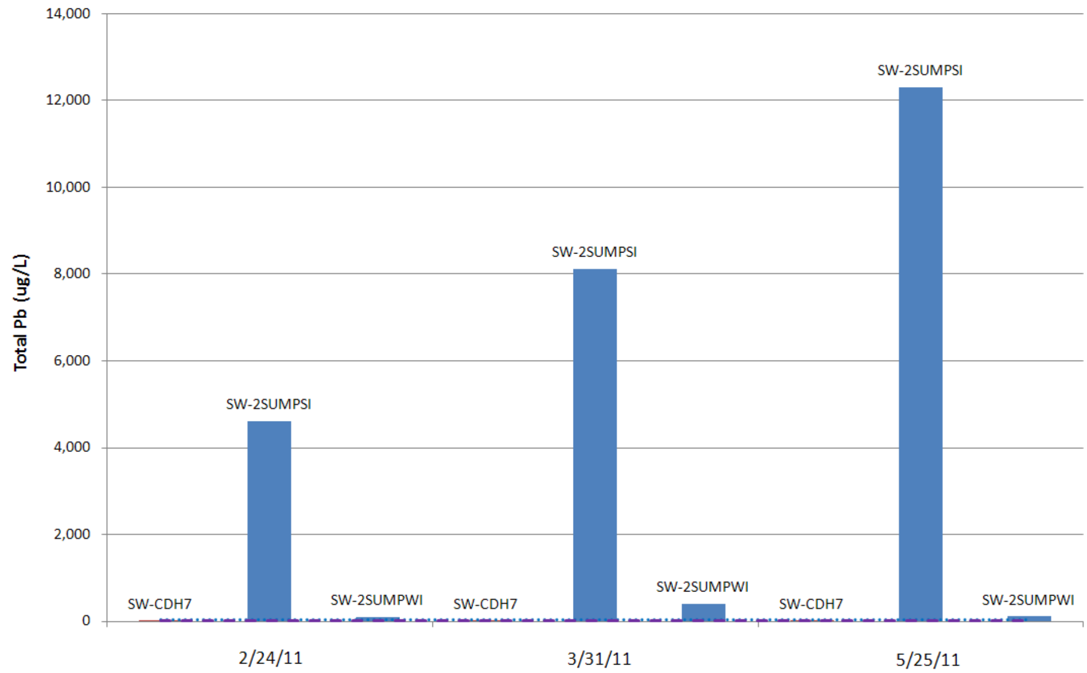


Figure 2-4. Incoming (sample location CDH7) vs. Outgoing (sample location SW-2-Sump) Mine Water Quality at Sweetwater Mine: Total Lead.

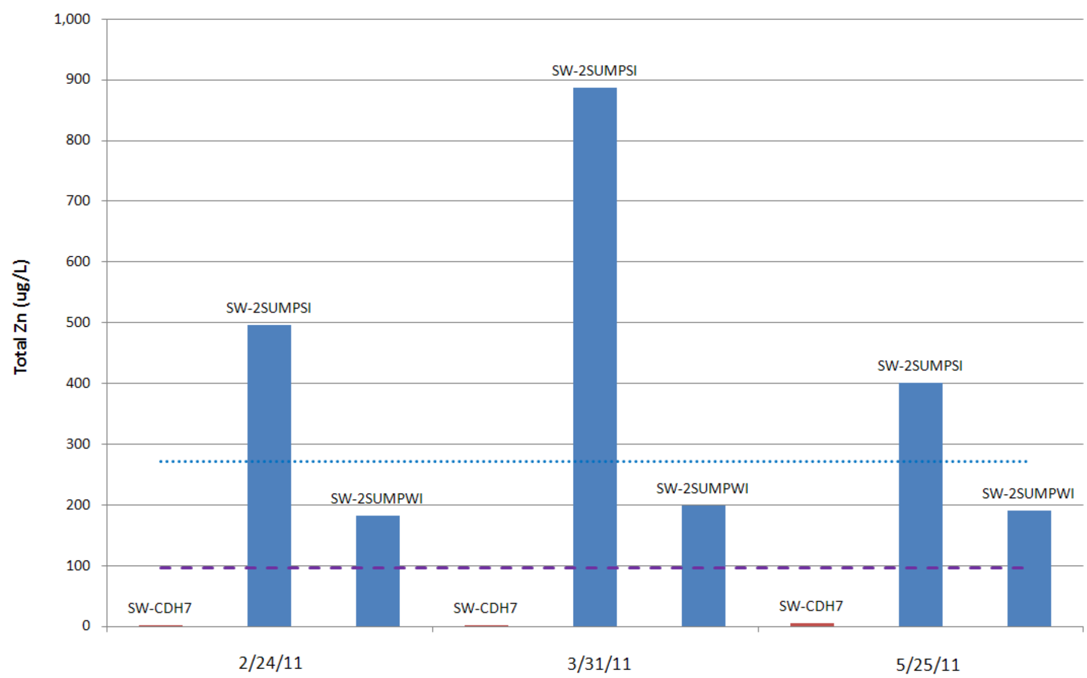


Figure 2-5. Incoming (sample location CDH7) vs. Outgoing (sample location SW-2-Sump) Mine Water Quality at Sweetwater Mine: Total Zinc.

2.2.3 Spatial Variation in Mine Water Quality

The mine water sumps in Sweetwater Mine are located between west and south branches of the mine and, as shown in Figure 2-1, most of the mine water that is pumped to the surface comes from the south branch. However, although the south branch of the mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the two branches. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the two branches were compared. The results of this comparison are shown in Figures 2-6 through 2-9.

Figures 2-6 through 2-9 compare box plots of the mine water quality between the west and south branches of Sweetwater mine. The box plots can be interpreted as follows:

- The dash in the center of each box represents the median value of the data set.
- The lower and upper edges of the box are the first and third quartiles (the first quartile represents the value that is equal to or greater than 25% of the data and the third quartile represents the value that is equal to or greater than 75% of the data), respectively.
- The lower and upper whiskers are the 5th and 95th percentile values.

For ease of comparison, each plot also shows the final effluent limits for that metal in the MSOP.

The following observations can be made from these plots:

- Cadmium: There does not appear to be a significant difference in cadmium content between the two mine branches. The range of cadmium concentrations in mine water spans the range of the daily maximum and monthly average final effluent limits; some samples were slightly higher than the limits, some were lower.
- Copper: Copper tends to occur at slightly higher concentrations in the west branch. The range of copper concentrations in mine water span the range of the daily maximum and monthly average final effluent limits; some samples were slightly higher than the limits, some were lower.
- Lead: Concentrations of lead in all mine water samples used in this comparison (which excludes incoming mine water) exceed the daily maximum and monthly average final effluent limits for lead. A much higher median total lead concentration was measured in the mine water samples from the south branch of Sweetwater Mine.
- Zinc: The median concentration of zinc in both branches exceeds the final monthly average effluent limit, but not the final daily maximum limit. In general, mine water from the south branch of the mine exhibits higher zinc concentrations.

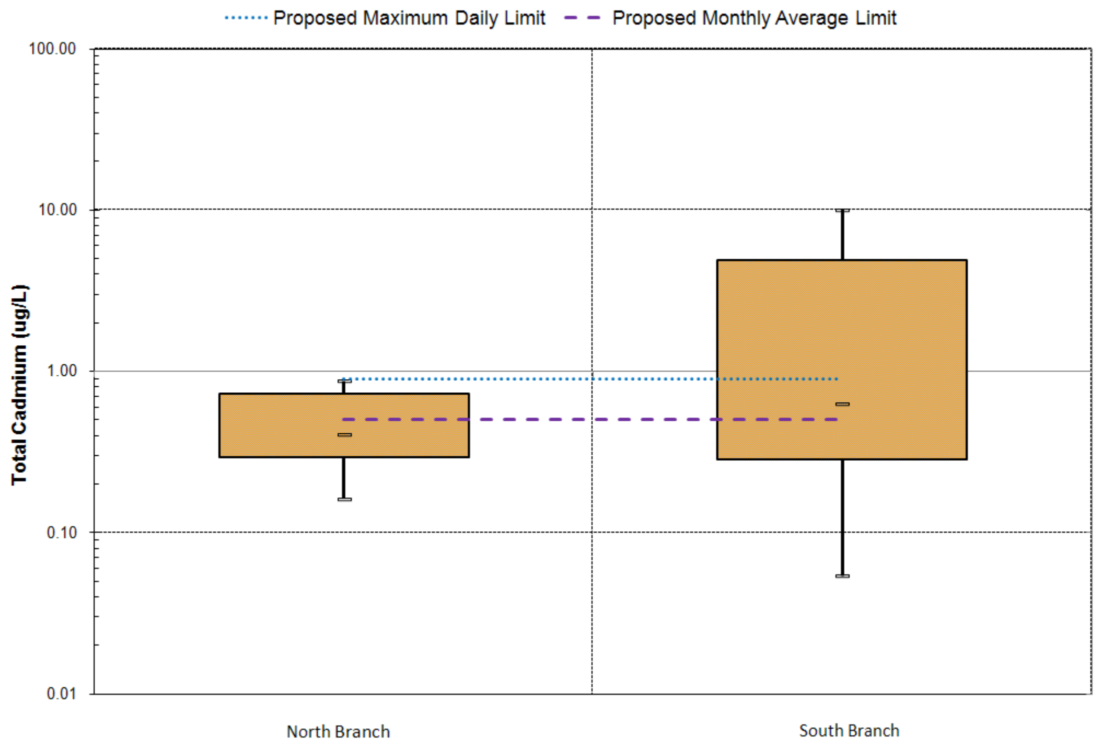


Figure 2-6. Comparison of Total Cadmium between West Branch of Mine and South Branch of Mine.

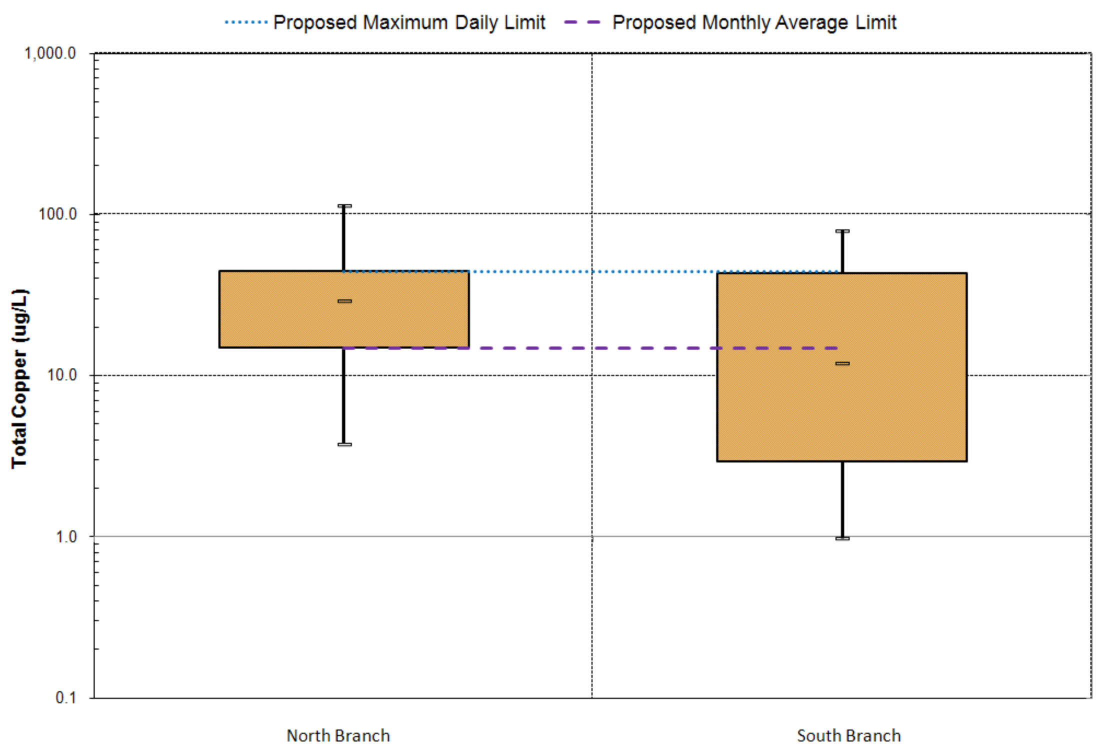


Figure 2-7. Comparison of Total Copper between West Branch of Mine and South Branch of Mine.

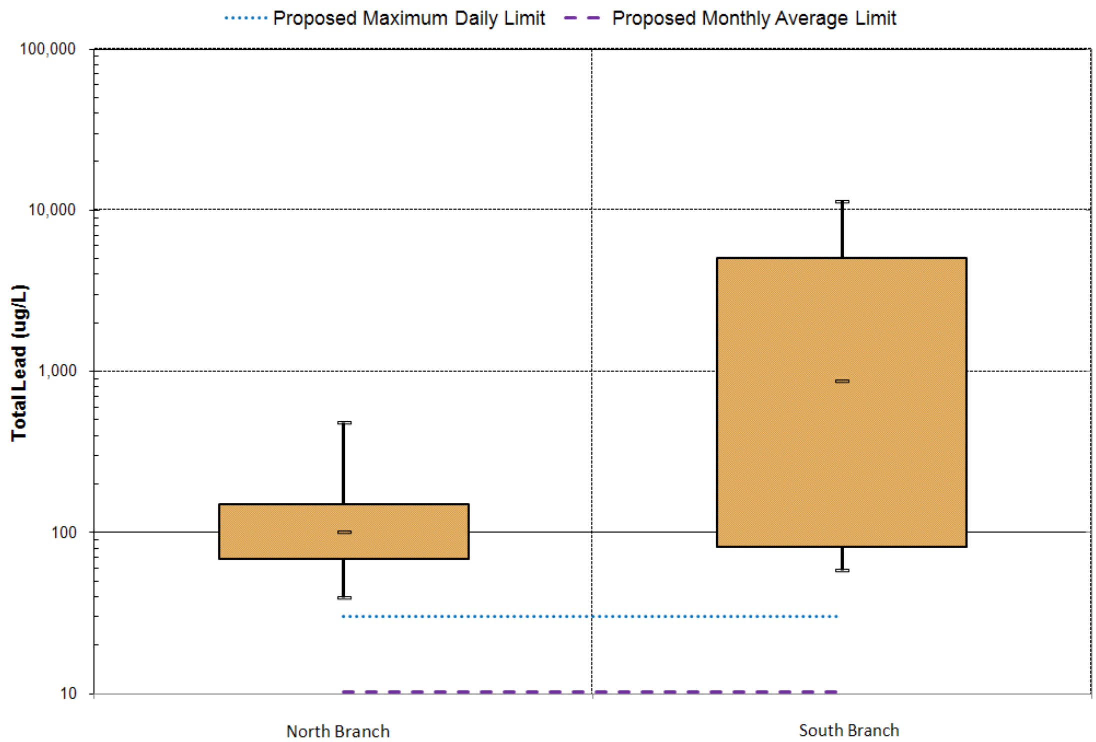


Figure 2-8. Comparison of Total Lead between West Branch of Mine and South Branch of Mine.

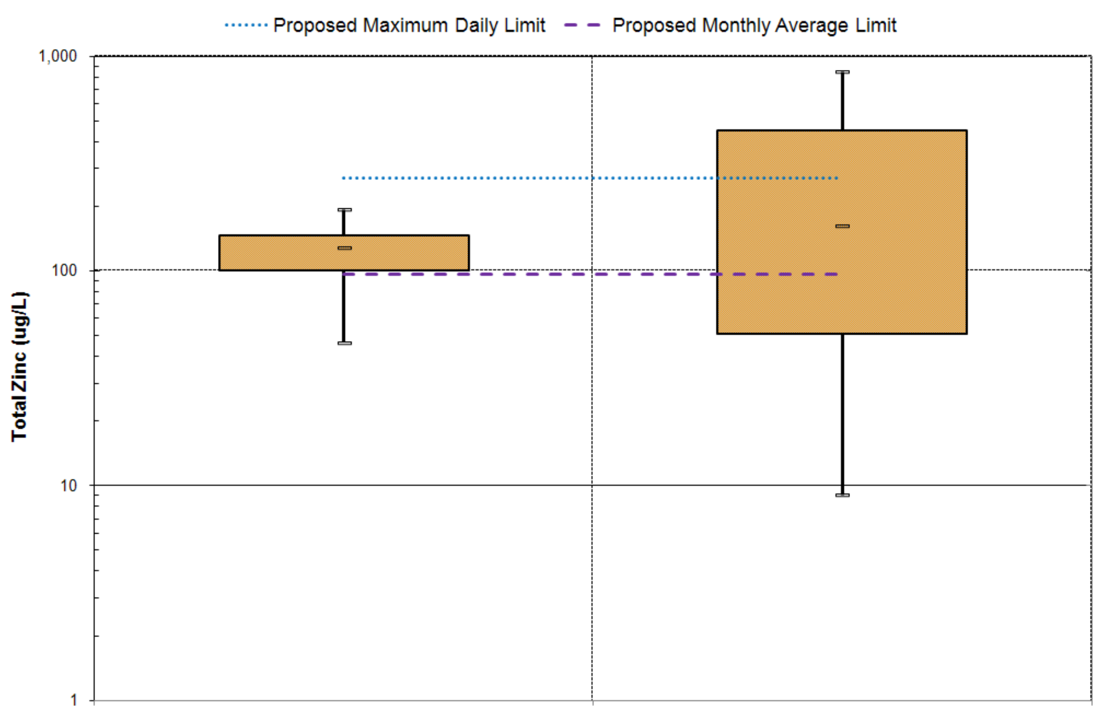


Figure 2-9. Comparison of Total Zinc between West Branch of Mine and South Branch of Mine.

Based on these comparisons, mine water in the two branches of Sweetwater Mine is not strongly differentiated with respect to cadmium, copper, and zinc. However, there does appear to be a difference between the two branches with respect to lead concentrations. The median total lead concentration in the south branch of the mine, for these data, was 878 μg/L compared to 101 μg/L for the west branch, and the maximum concentration was 22,250 μg/L in the south branch compared to 646 μg/L for the west branch. The higher lead values in mine water from the south branch of the mine, and that higher mine water flows come from the south branch, suggest that mine water control measures in the south branch of Sweetwater mine have a higher potential for effectiveness than in the west branch of the mine.

2.2.4 Relationship Between Solids and Metals in Mine Water

Data from Sweetwater Mine show that incoming mine water has relatively low metals concentrations compared to mine water that is pumped to the surface and that the concentrations are significantly increased by exposure to the mine workings (Section 2.2.2). Therefore, the Sweetwater Mine data were evaluated to assess the relationship between metals and suspended solids. Figures 2-10 through 2-13 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS).

These results show varying relationships of metals with TSS at Sweetwater Mine. The correlations are summarized in Table 2-5.

Table 2-5. Correlations of Total Metals with Total Suspended Solids at Sweetwater Mine.

Parameter	Correlation with TSS (r^2 value)
Cadmium, Total	0.72
Copper, Total	0.04
Lead, Total	0.78
Zinc, Total	0.14

The r-squared values[2] in Table 2-5 indicate that total cadmium and total lead are more closely correlated to TSS than copper or zinc. This suggests that increases in TSS, resulting from exposure of incoming mine water to mine workings, are a leading contributor to increases in cadmium and lead at Sweetwater. On the other hand, TSS does not appear to strongly affect concentrations of copper or zinc.

[2] One way of interpreting r^2 values is that if total cadmium has an r^2 value of 0.72 with TSS, then TSS explains 72% of the variability of total cadmium in the data set.

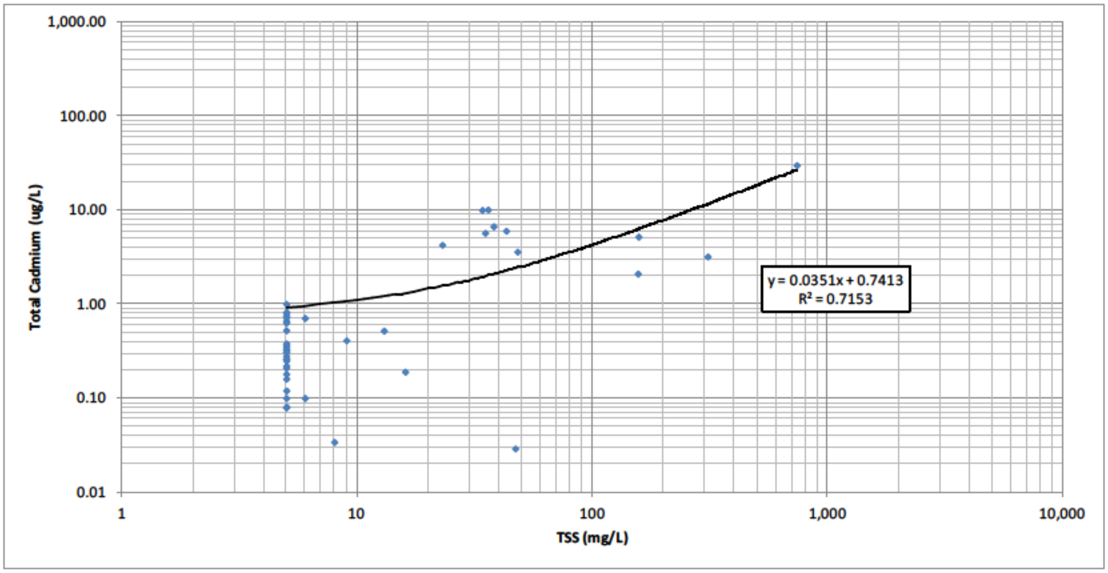


Figure 2-10. Correlation of Total Cadmium with Total Suspended Solids at Sweetwater Mine.

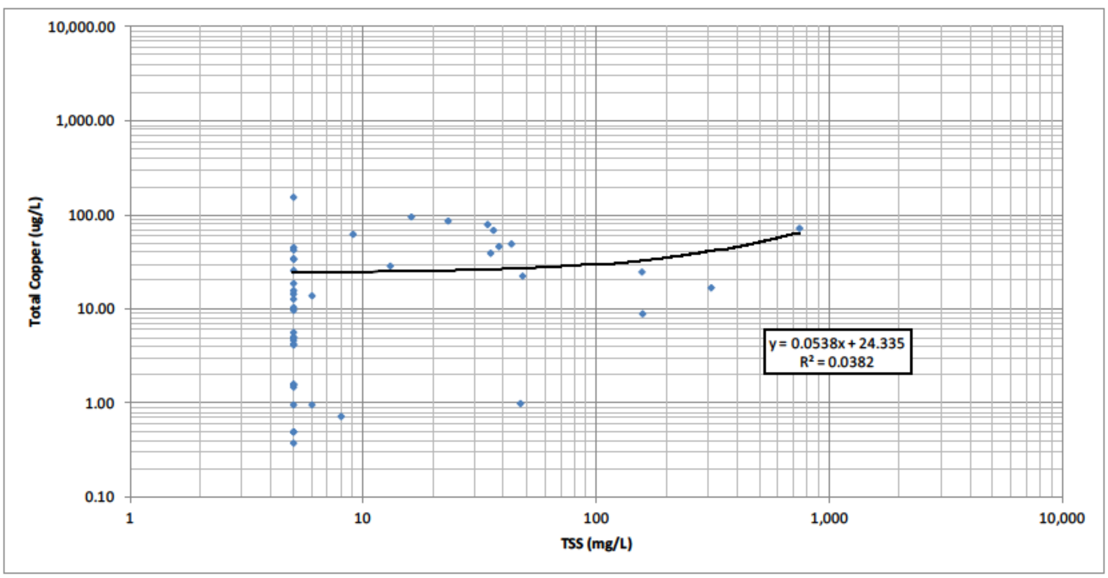


Figure 2-11. Correlation of Total Copper with Total Suspended Solids at Sweetwater Mine.

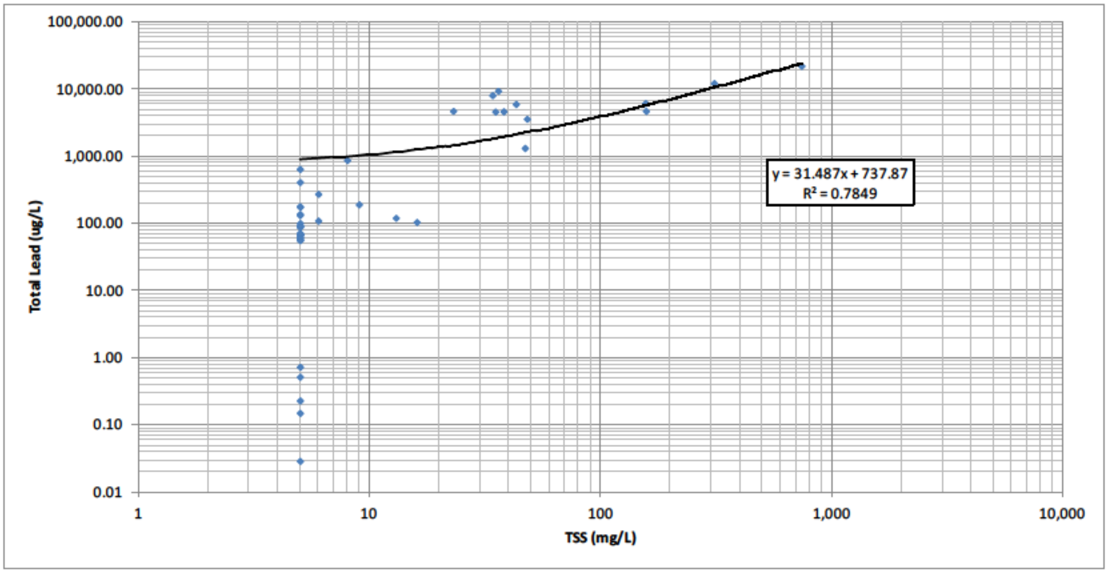


Figure 2-12. Correlation of Total Lead with Total Suspended Solids at Sweetwater Mine.

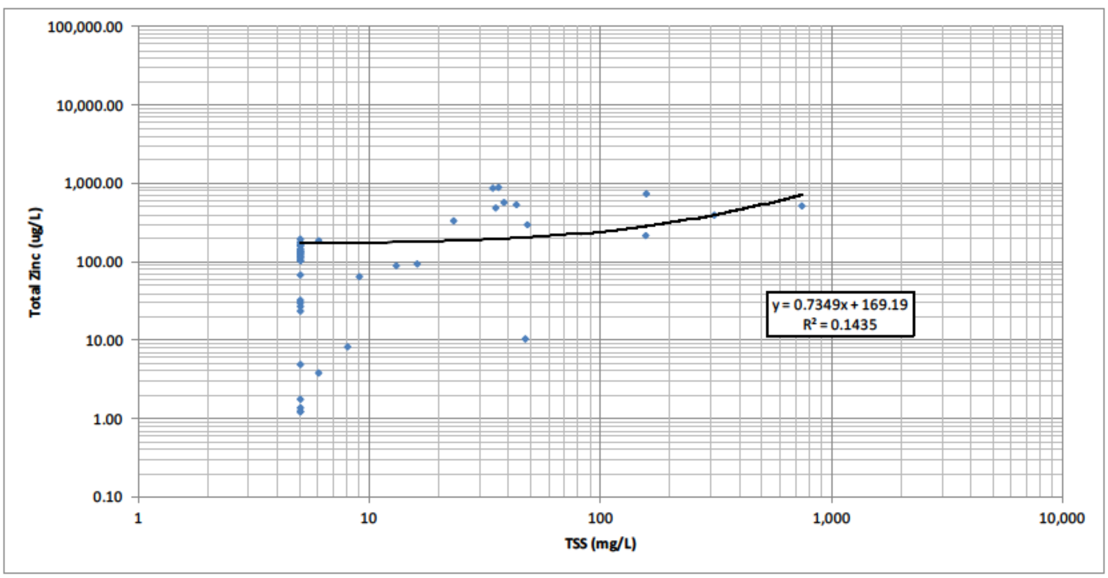


Figure 2-13. Correlation of Total Zinc with Total Suspended Solids at Sweetwater Mine.

2.2.5 Comparison of Underground and Surface Mine Water

Mine water data at the underground sumps at Sweetwater were compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. The results are plotted in Figures 2-14 through 2-17 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is not possible because the underground and surface samples were not collected on the same dates in every case and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made:

- The results indicate that total lead is generally higher in the underground mine water samples collected at the main mine water sumps than in the surface mine water samples. This is likely due to the lower suspended solids content of the surface mine water samples.
- The other metals (cadmium, copper, and zinc) all appear to be generally present at higher concentrations in surface mine water samples than in the underground mine water samples. There is no apparent explanation for this.

Ongoing sampling at Sweetwater will include underground and surface mine water and these data will continue to be evaluated as they are available.

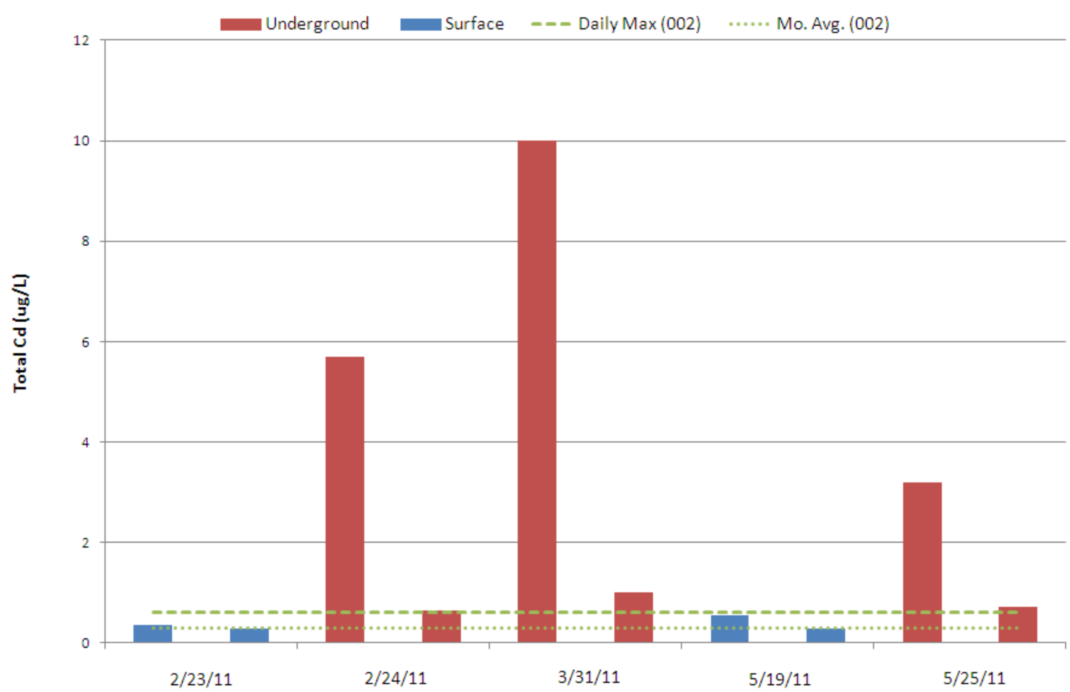


Figure 2-14. Total Cadmium in Underground (sample location SW-2-Sump) vs. Surface (sample locations SW-MWDischCulv and SW-MWConcreteBx) Mine Water at Sweetwater Mine.

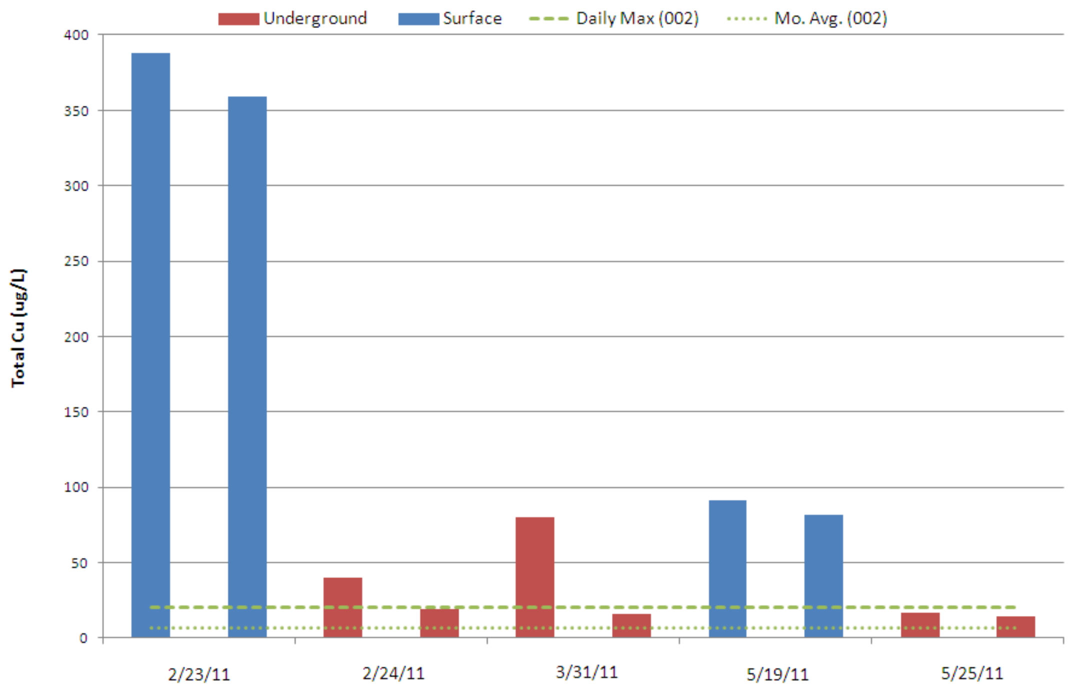


Figure 2-15. Total Copper in Underground (sample location SW-2-Sump) vs. Surface (sample locations SW-MWDischCulv and SW-MWConcreteBx) Mine Water at Sweetwater Mine.

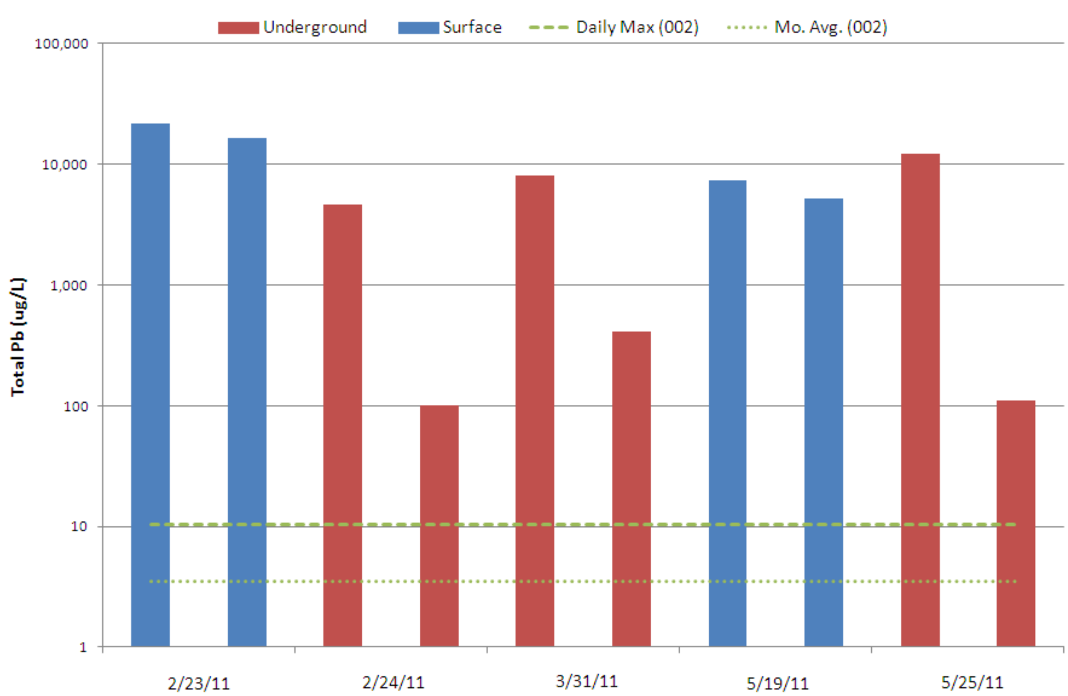


Figure 2-16. Total Lead in Underground (sample location SW-2-Sump) vs. Surface (sample locations SW-MWDischCulv and SW-MWConcreteBx) Mine Water at Sweetwater Mine.

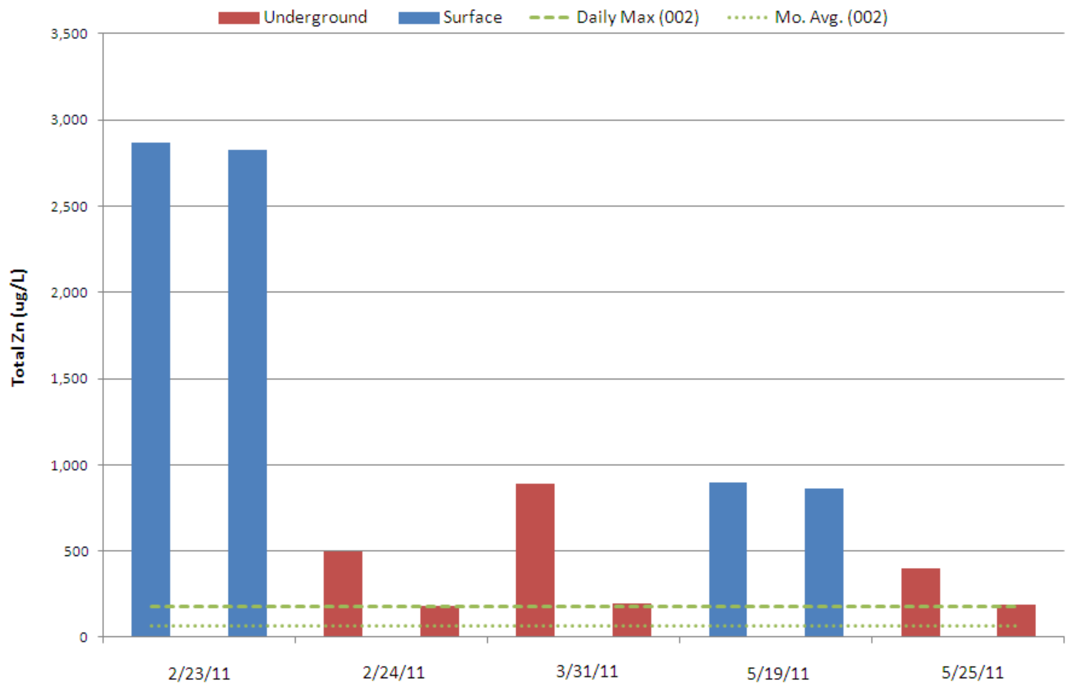


Figure 2-17. Total Zinc in Underground (sample location SW-2-Sump) vs. Surface (sample locations SW-MWDischCulv and SW-MWConcreteBx) Mine Water at Sweetwater Mine.

2.3 SUMMARY OF MINE WATER SOURCES AND CONDITIONS

The findings of the preceding discussion of mine water at Sweetwater Mine can be summarized as follows:

- The average flow of water entering Sweetwater Mine and being pumped to the surface is estimated at 2,500 gpm.
- Of this total mine water flow, approximately 80% of the flow comes from the South Branch of the mine.
- The single largest source of mine water at Sweetwater is ventilation shaft CDH7, which contributes about 1,000 gpm.
- Incoming mine water has relatively low metals concentrations, but exposure to the mine workings significantly increases those concentrations.
- Increased suspended solids in mine water appear to increase total lead and cadmium but has a significantly lower impact on total zinc and copper.
- Concentrations of lead in all mine water samples, excluding incoming mine water, exceed the daily maximum and monthly average final effluent limits for lead.

- The median concentrations of zinc in both branches exceed the final monthly average effluent limit, but not the final daily maximum limit.
- Much higher total lead concentrations were detected in the mine water samples from the south branch of Sweetwater Mine.

Some possible water management approaches for Sweetwater Mine for consideration as a result of these findings, include:

- Evaluate the effectiveness, technical feasibility and cost-effectiveness of reducing the flow of incoming water, especially in the south branch of the mine.
- Prioritize evaluations of options that are effective, technically feasible and cost-effective for managing water in the South Branch of Sweetwater Mine.
- Evaluate the effectiveness, technical feasibility and cost-effectiveness of measures that minimize exposure of water entering the mine to mine workings.
- Evaluate options that are effective, technically feasible and cost-effective to minimize the introduction of suspended solids to mine water in an effort to reduce total lead concentrations.

These water management approaches were used to evaluate potential water management measures, as discussed in Section 3.

This page is blank to facilitate double sided printing.

3. WATER MANAGEMENT MEASURES

This section of the plan presents several potential water management strategies and evaluates them in the context of Sweetwater Mine. In keeping with the Master Underground Water Management Plan, this section discusses the following types of possible measures:

- Isolation measures (Section 3.1)
- Treatment measures (Section 3.2)
- Groundwater interception (Section 3.3)
- Best management practices (Section 3.4)

A summary of the evaluation of these measures for Sweetwater Mine is presented in Section 3.5. It should be noted that this Section discusses potential underground water management measures and that these measures are not necessarily all planned for implementation at Sweetwater Mine. Section 4 describes which of these measures are planned for implementation and further evaluation of their effectiveness, technical feasibility, and cost-effectiveness Sweetwater Mine. It should also be noted that Doe Run is currently evaluating the technical feasibility and probable costs of treating mine water at the surface and these evaluations will provide a point of comparison with potential underground water management measures to evaluate the cost-effectiveness of those measures.

3.1 ISOLATION MEASURES

Isolation measures are measures designed to isolate mine water from materials/processes that have the potential to increase metals in the mine water. The objective of isolation technologies is to eliminate or reduce the potential for mine water to contact or be exposed to environments that have the potential to increase the metals load.

3.1.1 Piping Water

In many locations in the mine, mine water flows via gravity in roadside ditches. In some places in Sweetwater Mine, where it is necessary to pump water due to grade changes, the water flows through pipes. In areas where there is open water in ditches and piping is not used, the water surface is exposed to loading of solids and metals from the roadways, mobilized by passing trucks and machinery. Because of this potential exposure, piping presents a potential control measure for improving water quality.

Areas of Sweetwater Mine that are currently piped are shown on the map in Appendix A. In addition to what is shown on this map, additional piping from ventilation shaft CDH7 to #5 Sump is currently being considered. Piping used in the mine typically consists of high density polyethylene (HDPE) pipe, with 8-inch and 10-inch diameter (nom.) being the most common size used for long runs at Sweetwater. The unit cost for these pipe materials ranges from $7 to $10 per linear foot (l.f.) for 8” pipe and $11 to $17 per l.f. for 10” pipe. These are materials costs based on current vendor pricing and do not include labor for installation.

Review of sampling data from other Doe Run mines shows that water quality is reduced within a short distance of water entering the mine, which suggests that, for piping to be an effective control measure, water must be captured very close to the source before significant exposure to mine workings. This is not possible in every circumstance. However, piping may be implemented on a localized basis at the Sweetwater Mine as a water quality management measure where the company determines that the measure will be effective in controlling water quality and will be cost-effective.

3.1.2 Lined Channels

Roadside channels in the mine allow contact between flowing water and the underlying rock. This contact may cause an increase in metals concentration, so lining of the channels was evaluated. Lining would involve placement and anchoring of an impermeable material on the bottom of the ditch to prevent the water-rock contact. This approach has not been tested but it may be less effective than piping because it only addresses the issues of contact between flowing mine water and underlying rock, whereas piping should isolate mine water from the surrounding mine workings, as well as the underlying rock. In addition, sediment could accumulate in the lined channel over time and defeat the purpose of the lining. For these reasons, channel lining is not considered for evaluation as a potential water quality control measure for Sweetwater Mine.

3.1.3 Work Area Isolation

As described in the Master Underground Water Management Plan, work area isolation includes “isolating or compartmentalizing those areas to prevent the migration of materials into the water conveyance system”. The master plan suggests work areas may be separated from the remainder of the mine by physical measures such as berms, entrance tunnel modifications, or preplanning of new mine area configurations.

The feasibility of these potential measures was discussed with mine personnel. The challenge to implementing these measures is that they will interfere with mining operations. For example, berms placed between drilling or ore loading areas and water drainage channels will interfere with the passage of vehicles. It is impractical to build the berms up and tear them down every time a vehicle or piece of machinery needs to leave the work area. Entrance tunnel modifications and new mine area preplanning involve designing tunnels so that a high point exists between work areas and the rest of the mine, to prevent the drainage of water impacted by mining activities from leaving the work area. This technique is impractical in most cases because the prevention of mine water drainage from work areas will result in flooding of those work areas. For the reasons discussed above, work area isolation is not considered for further evaluation as a possible water quality control measure for Sweetwater Mine.

3.1.4 Capture of Drill Fines

The Master Underground Water Management Plan also identified the capture of drill fines as a potential control measure. As stated in the Master Underground Water Management Plan, drilling is conducted for both mine development and ore recovery operations and the drilling process produces fines which have the potential to become suspended in mine water. Three types of drilling are used at Sweetwater Mine:

- Jackhammer drilling is a percussion drilling method used for exploratory drilling in the mine. This is a “wet” drilling technique that generates fine material from the borehole that is carried away from the borehole by water.
- Core drilling is a second exploratory drilling technique that uses water- to flush fines away from the core barrel and bit to extract a rock core form the borehole. Drill fines are generated during drilling and carried from the borehole by water.
- Production drilling is a percussion drilling method used during mining operations that can be either air mist or water cooled. Fines are generated in the borehole and carried out of the borehole by water or air.

In general, the quantity of fine materials generated during drilling is relatively small and the water generated during wet drilling is very small relative to other sources of flow in the mine. It is generally infeasible to capture drill fines from any of the above techniques because any method used to capture these fines would substantially interfere with drilling operations. For these reasons, capture of drill fines is not considered for further evaluation as a possible water quality control measure for Sweetwater Mine.

3.2 TREATMENT MEASURES

One type of underground water control measure considered for improving mine water quality is to actually treat the mine water below ground. Treatment processes that may have the potential to improve the quality of mine water include clarification (settling) and filtration.

3.2.1 Clarification

Clarification is a treatment process that involves the removal of suspended solids from water by gravity settling. Simple clarification typically involves the use of basins or sumps that reduce the velocity of flowing water, which allows a portion of suspended solids to settle. Enhanced clarification usually involves the addition of chemicals to facilitate coagulation and flocculation of fine particles that will not settle on their own. These processes are described below:

- Coagulation is the process of adding chemicals to neutralize particle charges that keep particles dispersed. Once the charges of fine particles are neutralized, they will bind together more readily, forming larger particles. This process is often used when very fine particles are suspended.

- Flocculation is the process of providing suitable conditions for fine particles to bind together and often involves very gentle mixing.

Simple clarification is practiced in the Sweetwater Mine, in the form of mine water sumps. These sumps are located throughout the mine and acts as settling basins. Simple clarification in the form of mine water sumps will be part of the overall mine water management plan for Sweetwater Mine.

Enhanced clarification using chemicals for coagulation/flocculation, on the other hand, can be a complex process, requiring careful monitoring, with addition of chemicals to adjust the pH of the water being treated for optimization of treatment, followed by readjustment of pH. The process of enhanced clarification results in residuals that are much more difficult to handle and dewater than simple clarification. Providing suitable conditions for settling of the flocculated solids typically requires specialized clarifiers. The challenges of this more complex form of water treatment underground are discussed in Section 3.2.3.

3.2.2 Filtration

Filtration refers to the process of physically separating suspended solids from water by passing the water through material that has openings finer than the suspended materials. This can be accomplished using granular filter materials (e.g., sand filters), woven fabrics, or fabricated plastic or metals filters. The advantage of filtration over clarification is that it results in a more complete separation of water and solids, with the residual solids having lower water content than the residuals of clarification.

Filtration of mine water can potentially be accomplished underground in two ways. First, filters can be used between water sources and water conveyances, to remove suspended solids nearer the source. Second, filtration could be used as a centralized treatment process, immediately prior to pumping of mine water to the surface. The use of filtration between water sources and conveyance systems may have potential underground and may be part of the underground water management plan at Sweetwater Mine. Examples of this are the use of sand berms between flowing coreholes and water collection areas, and filter fabric wrapped around perforated HDPE drainage piping along roadways. Centralized filtration of mine water faces similar challenges as other centralized water treatment processes underground, which are discussed in the following section.

3.2.3 Overall Assessment of Underground Mine Water Treatment Feasibility

Mine water treatment processes, such as filtration between water sources may be feasible treatment practices for mine water underground. Still, further evaluation is needed to determine the impact of these practices on mine water quality and whether or not they are cost effective. Clarification by means of centralized mine water sumps is currently used at Sweetwater Mine and will continue to be a part of the overall water management plan. However, other forms of centralized (i.e., large-scale) underground mine water treatment present several challenges including:

- Available space – Centralized treatment will require a substantial amount of space in the mine. While space is often readily available at the surface, it must be created in the mine by excavating rock. Areas where mining has already occurred are not good candidates because of the possibility that Doe Run may want to return in the future and extract pillars. New areas are expensive to create; the estimated cost of excavating rock underground is $0.60 per cubic foot (c.f.). In order to build only a sump, approximately a half million cubic feet of rock would need to be excavated, and that only includes the space needed to contain the water. In addition, because the same equipment and personnel would be used to excavate the area for treatment as would be used for mining there is a cost in lost ore production.

- Protection of treatment processes – It would be difficult to prevent treatment processes from being exposed to airborne dust in the mine, which could cause additional metals loading to the treatment system or otherwise upset the processes.

- Specialized operators – The types of treatment that would be required to reduce metals in mine water, aside from simple settling, would likely require trained operators. Such personnel are not currently deployed underground by Doe Run and their deployment underground would be more costly than above ground.

- Management of residuals – One of the biggest challenges for underground mine water treatment is the management of residuals. Although settled materials can be managed using conventional construction equipment, materials settled by flocculation have higher water content and would likely require specialized equipment. In addition, because they are flowable, they would require larger areas for disposal (i.e., they cannot be piled).

The use of mine water sumps for clarification (both distributed throughout the mine and at centralized locations prior to pumping to surface) will both be part of the underground water management plan for Sweetwater Mine. Other types of centralized underground mine water treatment do not appear to be feasible at Sweetwater Mine because of the challenges outlined above and will not be evaluated further.

3.3 GROUNDWATER INTERCEPTION

Groundwater interception is used here to include all measures that prevent water from entering the mine. Water can enter mine areas in a few ways:

- Coreholes – This refers to exploratory borings advanced from the surface to mine depth or from within the mine into the mine face, used to identify ore locations and direct mining activities. Coreholes sometimes intercept fractures and voids in the rock that convey water and then act as drains to allow water from the rock to enter the mine.

- Access and vent shafts – These are large-diameter shafts constructed from the surface to mine depth to allow access by personnel and equipment, removal of ore, and ventilation of mine areas. Because they intercept overlying aquifers and penetrate aquitards between the overlying aquifers and the mine, they can become major water sources to the mine. Casing is usually installed in these shafts, which greatly reduces flows. Flows into these shafts can also come from storm water at the surface, although this contribution is relatively small compared to other flows.

- Fractures – Rock fractures are naturally occurring and mining activities at Sweetwater occur in an aquifer to begin with, so it is common for those mining activities to intersect water-bearing fractures. When this occurs, the fractures become a means of water entry into the mine.

The primary methods available to intercept groundwater before it enters the mine are sealing of coreholes and fractures, casing of shafts, and aquifer dewatering to prevent groundwater from entering coreholes, shafts, and fractures.

3.3.1 Corehole and Fracture Sealing

When mining operations intersect coreholes and fractures, they can become a source of water to the mine. This can be true for a surface corehole if the corehole was incompletely sealed after drilling or if the seal has somehow failed over time. The Doe Run standard operating procedure for exploratory coreholes requires that coreholes penetrating the Davis shale must be fitted with an expandable packer within the bottom part of the formation and the hole must be filled with grout to at least 50 feet above the top of the Davis formation. The standard operating procedure remains in effect.

If a leaking corehole is encountered during mining operations, the corehole can sometimes be sealed using mechanical packers or grout. Mechanical packers have historically been used and have been shown to be effective, although in some cases stopping the flow from a corehole has caused the flow to enter the mine elsewhere. Sweetwater Mine personnel may plug coreholes that yield significant flow when they are encountered during mining. Doe Run has been evaluating the use of chemical grouts. Two types of chemical grout have been tested at the Fletcher Mine with limited results:

- Two-part grout: This is a two-component grout sold under the trade name H2OSTOP and it has been used for high-inflow coreholes. The grout reacts and sets within seconds of mixing, which is accomplished during injection by a static mixer inside a packer that is inserted in the corehole. The grout can expand in volume up to 20:1 and costs about $195 per cubic foot.
- Moisture-reactive grout: This is a single component grout sold under the trade name Hyperflex that sets in contact with water and is used for lower flow applications. This grout can also expand in volume up to 20:1 and costs about $397 per cubic foot.

These grouts can be effective for sealing fractures as well. Vendor information for both of these products is included in Appendix B. There is no reliable way to estimate how much material will be required to grout a corehole; in the last year, an estimated 200 cubic feet of product has been used. Corehole and fracture sealing will be a part of the underground water management plan for Sweetwater Mine, where it is feasible, technically possible and cost-effective to do so.

3.3.2 Shaft Sealing/Repair

Because access and ventilation shafts are necessary for the safe and productive operation of the mine, they cannot be eliminated. Although it is not possible to completely seal the shaft to prevent any water from entering the shaft (and therefore the mine), the standard practices employed by Doe Run are usually capable of eliminating most of the flow. These practices involve the installation of casings in the shafts to seal out water. In some cases, however, these casings may fail, as is the case for ventilation shaft CDH7 at Sweetwater Mine. As discussed in Section 2.1.2, the casing in CDH7 ruptured several years ago and it has been flowing at about 1,000 gpm since then. Significant reduction of the flow might be accomplished by repair of the casing by sealing the rock formation behind the ruptured casing. Evaluating the cost-effectiveness, feasibility, and impact on mine water quality of repairing CDH7 is part of the underground water management plan for Sweetwater Mine and is addressed in Section 4.

3.3.3 Aquifer Dewatering

The only other potential flow reduction measure to prevent water from entering the mine is interception of the groundwater in the aquifer before it reaches the mine. This would require installation of dewatering wells at critical points around the mine, at the depth of the contributing aquifers, and pumping of groundwater from the wells. Implementation of aquifer dewatering is a substantial and costly undertaking that would typically only be evaluated for very large sources of flow. Aquifer dewatering would require the following steps:

- Hydrogeological investigation to fully characterize water-bearing units around and above the mine.
- Installation of pumping wells to test the rates at which water could be pumped from the aquifer and the drawdowns in potentiometric surface that could be achieved.
- Evaluation of the ability of pumped groundwater to meet surface water discharge limits.
- Upon completion of the above testing, the dewatering system would be designed and constructed.

One major advantage of this approach is that it involves pumping of groundwater to the surface before it comes into contact with the mine workings. This would presumably eliminate the need for treatment at the surface, prior to discharge. Aquifer dewatering is a potentially effective measure for major water sources. It is likely not feasible, however, to use aquifer dewatering for an entire mine, miles in length, due to the costs involved. Localized aquifer dewatering may potentially be used as a short-term measure to temporarily reduce flow in order to facilitate repairs on shaft casings.

3.4 BEST MANAGEMENT PRACTICES

There are several underground water management practices that can potentially be used to maintain or improve mine water quality. These are referred to as best management practices (BMPs) and several were identified in the Master Underground Water Management plan, including the following:

- Berms
- Channels
- Collection and Containment of Impacted Water
- Clean Mining Areas
- Material Handling and Storage
- Erosion Control
- Roadway Maintenance
- Maintenance Schedules

In addition, sump cleaning and inspection were identified as BMPs that should be considered. These BMPs are discussed below.

3.4.1 Berms

The use of berms was discussed previously in this plan (Section 3.1.3). Because even temporary berms will interfere with the movement of vehicles and equipment in the mine, where working space is already limited, it does not appear that their use is feasible, except in situations where flows can be directed to inactive mining areas, which is already done at Sweetwater Mine.

3.4.2 Channels

Shallow channels are already used throughout Sweetwater Mine to convey mine water flows. As discussed in Section 3.1.2, these channels are already problematic because they expose mine water to more impacts from mine workings. The potential for replacing open channels with enclosed pipes will be discussed in Section 4.

3.4.3 Collection and Containment of Impacted Water

Once water is impacted by exposure to mine workings, it should be isolated from unimpacted water. For example, if impacted water is created at the working mine face during ore extraction operations, it should not be mixed with unimpacted water seeping from coreholes, if this can be avoided.

3.4.4 Clean Mining Areas

In general, maintaining clean mining areas may help reduce the potential for mining activities to impact mine water. This “good housekeeping” practice will be employed to the extent possible in all mining areas and may include storage of ore, drill fines, waste rock, and mining equipment away from areas where water is collected.

3.4.5 Material Handling and Storage

This BMP refers to practices for handling and storage of materials that have the potential to impact mine water quality. This may include stockpiled ore or it may include solids removed from sumps during mucking. The practice for storing such material stockpiles will be that they are placed so as to minimize impacts to mine water.

3.4.6 Erosion Control

As described in the Master Underground Water Management Plan, erosion control in mines includes the protection of any surface that has the potential to erode and increase the loading of suspended solids. These areas include material storage piles and transportation corridors. At Sweetwater Mine, erosion control of storage piles will be addressed by material handling and storage practices and erosion control of transportation corridors will be addressed to the extent feasible by the roadway maintenance program.

3.4.7 Roadway Maintenance

The heavy traffic of trucks and mining equipment over mine roadways, which are normally constructed of crushed rock, can result in erosion of the road surface. This can have two related impacts on mine water quality. First, the erosion of road materials can move fine materials into roadside channels filled with water. Second, the erosion can result in a lowering of the road bed over time, which can eventually lead to flooding of the eroded part of the road. Regular inspection of roadways and prompt repair of eroded areas will be part of the underground water management plan for Sweetwater Mine.

3.4.8 Maintenance Schedules

Scheduling of maintenance activities related to underground water management at Sweetwater Mine will be driven by monitoring and inspection activities, as discussed in Section 4.

3.4.9 Sump Cleaning

At Sweetwater Mine, like all Doe Run mines, mine water flows via gravity and/or pumping to central sumps where it is then pumped to the surface. At Sweetwater Mine, the central mine water sumps are #2 Sump and A-area Sump. A-area Sump is relatively new, having become operational in 2011. This is a 2-cell sump with greater storage capacity than #2 Sump. Currently, water from #2 Sump is pumped to A-area Sump and approximately 2,500 gpm is being pumped from A-Area sump to surface.

All mine water sumps provide temporary storage for mine water and, as a result, can have potential for settling solids, proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids, by design. This means, however, that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, accumulated solids could eventually impair pumping. For these reasons, periodic maintenance of the sumps is required to remove solids. The process of sump cleaning is referred to as “sump mucking”.

Sump mucking involves temporarily draining the sump, then mechanically removing the accumulated solids from the sump. The solids are transported to an inactive area of the mine for storage, where they dewater by gravity drainage. Since they consist of fine rock and ore, the dewatered solids are sometimes added to the mined materials sent to the surface for processing.

Experience at Doe Run mines shows that sump cleaning results in excessive wear on the machinery that is used to remove the accumulated solids because the fine solids get into the mechanical and hydraulic components of the machinery and are abrasive. At Sweetwater Mine, a specialized excavator is required and the machine has to be refurbished after every sump mucking event. The cost of this extra mechanical maintenance is estimated at $50,000 per event. Because sump cleaning is a necessary component of mine operations, it will be continued in the future and is discussed further in Section 4.

3.4.10 Inspections

Regular inspection of mine water management measures will be an important part of the overall underground water management plan at Sweetwater Mine. These inspections will be used to monitor effectiveness of the plan and to identify the need for maintenance of roadways, piping, sumps, and other mine water management measures.

3.5 SUMMARY OF WATER MANAGEMENT MEASURE EVALUATION

Several of the potential control water management measures have been identified for the Sweetwater Mine as they may have the potential to reduce mine water flows and effect improving water quality. The measures are summarized in Table 3-1 along with notation on which will be part of the Sweetwater underground water management plan. In all cases, the use of the measures discussed here will be evaluated and implemented if Doe Run determines that the measures are effective, technically feasible, and cost effective, or will be further evaluated for potential implementation.

Table 3-1. Summary of Water Management Measure Evaluation for the Sweetwater Mine

Type of Measure	Measure	Assessment Summary	Included in Sweetwater UGWMP?
Isolation	Piping	Potentially effective on a localized basis; will undergo further evaluation	Yes
	Channel lining	Not an effective control measure	No
	Work area isolation	Not feasible	No
	Capture of drill fines	Not feasible	No
Treatment	Clarification	Simple settling feasible; enhanced clarification infeasible	Yes
	Filtration	Potentially feasible on a localized basis; will undergo further evaluation	No
Groundwater Interception	Corehole/fracture sealing	Potentially effective, will undergo further evaluation	Yes
	Shaft repair/sealing	Potentially effective, will undergo further evaluation	Yes
	Aquifer dewatering	Potentially effective, will undergo further evaluation	Yes
Best management practices (all to undergo regular review and evaluation)	Berms	Useful in some case	Yes
	Channels	Necessary, piping preferred in some areas	Yes
	Collection/ containment	Potentially useful	Yes
	Clean mining areas	Potentially useful	Yes
	Material handling/storage	Potentially useful	Yes
	Erosion control	Addressed by material handling & roadway maintenance	No
	Roadway maintenance	Potentially useful	Yes
	Maintenance schedules	Necessary, driven by monitoring and inspections	Yes
	Sump cleaning	Necessary	Yes
	Inspections	Necessary	Yes

This page is blank to facilitate double sided printing.

4. PLAN ELEMENTS AND IMPLEMENTATION

The underground water management plan for Sweetwater Mine is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of potential measures focusing on cost-effectiveness and impact on water quality;
- Development of planned actions;
- Implementation of planned actions;
- Monitoring of implemented actions (data collection and inspection);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Sweetwater Mine plan discussed in this section are:

- Water management actions
- Best management practices
- Monitoring
- Inspection
- Recordkeeping
- Training
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections. It should be noted that mine water treatment evaluations are ongoing at Doe Run. The outcome of these evaluations will determine the most effective mine water treatment method, as well as an accurate estimate of the unit cost for mine water treatment. This will allow evaluation of potential underground water control measures in the context of relative cost-effectiveness, compared to treatment at the surface. Based on these comparisons, some of the measures discussed in this section may be determined not to be cost effective and may be removed from the plan in the future.

4.1 WATER MANAGEMENT ACTIONS

Based on the review of mine data discussed in Section 2 and the evaluation of potential control measures discussed in Section 3, several water management actions are being evaluated for the Sweetwater Mine, as discussed below.

4.1.1 CDH7 Flow Reduction

As described in Section 2.1.2, the ruptured casing in ventilation shaft CDH7 is responsible for almost half of the mine water currently entering Sweetwater Mine, approximately 1,000 gpm. This represented the single biggest opportunity for reducing mine water flows from the mine. It is known the casing is ruptured approximately 500 feet below the surface. In August 2012, Doe Run began a grout feasibility analysis in lieu of the pumping test described in the previous UWMP. This analysis included drilling a series of test holes to observe the conditions in the immediate area of the shaft to determine if chemical grout could be used to block the inflow of the water into the water conduit of the shaft. After completion of this analysis, Doe Run determined that the chemical grouting is not the best option for reducing flow at this time. Other potentially effective alternatives for eliminating flow from CDH7 are currently being explored.

4.1.2 Corehole Sealing Program

Mine personnel may seal coreholes when it is feasible. This plan formalizes the framework for determining which coreholes will be sealed. New coreholes that are encountered during mining operations that produce significant flows to the mine may be sealed, if sealing is technically possible and cost-effective. If possible, the following procedure will be followed:

- Flowrate from the corehole will be estimated by measuring the time required to fill a 55-gallon drum or other similarly-sized container of known volume. If it is not possible to measure the flowrate from the corehole in this manner due to the location of the corehole and difficulty in positioning the container under the stream of flow, a 5-gallon bucket or similar smaller container shall be used. If this is also impractical due to the very small quantity of flow or for safety reasons, the underground water management team will discuss alternate flow estimation methods. Because flows from newly encountered coreholes sometimes vary, the flow will be measured once a month for three months.
- The diameter of the corehole will be measured to the nearest inch. If it is impossible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.
- After measuring the flow and the corehole diameter, the underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past. If the underground water management team is not certain whether sealing is feasible, they will consult with manufacturer's representatives for mechanical plugs and grouts to help determine the feasibility of sealing the corehole.
- If it is determined that the corehole can be sealed, the underground water management team will determine a schedule for sealing that takes into account the priority of the action relative to other water management measures.

The above process is documented in the form of a standard operating procedure, included in Appendix C. Corehole sealing will be documented in writing. The methods and procedures used for sealing will be documented, along with problems encountered and apparent success of the sealing, for future reference.

4.1.3 Piping

Where likely to protect water quality and where Doe Run determines it will be feasible and cost-effective, major mine water flows may be piped. Installation of piping from ventilation shaft CDH7 to #5 Sump is planned, but the project is contingent upon the success of the grouting project at CDH7 as well as economic feasibility. Piping has already been installed from #5 Sump to the A-Area sump, so if this piping project does occur, mine water from CDH7 will be piped from its source to A-Area sump, where it is pumped to the surface.

As described elsewhere, data collected from CDH7 shows that the incoming water has very good quality, based on samples collected from the containment area at the base of the vent shaft. Water quality has continued to be monitored at CDH7, as well as at #5 Sump. Because the overall pipe route from CDH7 to A-Area sump is separated into two legs by #5 Sump, the data will show whether water quality is degraded in #5 Sump itself.

Data collected at Doe Run mines indicate that the quality of mine water entering mines can be degraded within a short distance of the point of entry. Therefore, before piping to maintain water quality, the underground water management team will continue to determine whether the piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation. This will likely be accomplished by containing the water at the point of entry with a sump or other system and piping directly from the sump to a main mine water sump.

If the source of the incoming water is a corehole, the procedures outlined in Section 4.1.2 will be followed before piping is evaluated. If the source of the water is a corehole that cannot be sealed, the underground water management team will use the following protocol to determine whether piping will be installed:

- The physical setting and surroundings of the source will be assessed by the underground water management team to identify options for containing the incoming flow as close to its source as possible. This process will consider space availability, accessibility of the source, quantity of flow, other mine operations, cost, and safety.
- Once the most feasible and cost-effective option for containing the flow is determined, the underground water management team will determine the flow path the water will follow to reach the containment area. Water samples will then be collected at the end of that flow path, at the point where water would enter the containment area, as well as the point of entry to the mine (i.e., the corehole, fracture, or shaft). This water sampling will follow the standard procedures for sampling that are currently in place for water sample collection.

- The sampling results will be compared to the results for the incoming water as a measure of the water quality degradation that will occur along the flow path to the location of the containment. The results will also be compared to water quality data from the mine water sump to which the water would be piped. The underground water management team will use these comparisons to determine whether the piping is likely to provide a significant water quality benefit and whether the piping is cost-effective.

All data collected during piping evaluations will be recorded. Upon review of new data in the future, if a piping project is determined to be ineffective, the piping project may be terminated or, if already installed, the piping may be removed for use elsewhere.

4.1.4 Ongoing Water Management Measure Evaluations

In addition to the measures discussed in the preceding sections, the following additional actions will be considered on an as-needed basis:

- Additional piping – As mine expansion occurs, significant inflows of relatively clean groundwater may be encountered and, in some cases, it may be feasible and cost-effective to contain the water locally and pipe it directly to mine water sumps. This measure will be evaluated by the water management team on a case-by-case basis.
- New corehole sealing techniques/materials – The water management team will continue to evaluate new techniques or materials for corehole sealing, as they become available.
- New mine water pump shafts – As mining operations progress, it may become feasible to construct new pump shafts to the surface, as an alternative to moving water from newly mined areas to existing mine water sumps. This will be evaluated by the water management team on an as-needed basis.
- Mine expansion – During mine expansion activities, mine personnel will consider water management strategies from a water quality, as well as logistical perspective and identify environmentally-appropriate water management strategies into the expansion design.

As with the planned activities described in the preceding section, control measure evaluations will be documented in future updates to this plan.

In addition to actions outlined above, BMPs, as described in Section 4.2, will be used to manage water quality.

4.2 BEST MANAGEMENT PRACTICES

Several BMPs will be implemented at Sweetwater Mine as part of this plan, as described in the following sections. Some of these BMPs, such as berms, channels, collection, and clean mining areas will likely be used relatively infrequently because of their limited applicability. Others, such as roadway maintenance and sump cleaning will be performed more frequently, but still on an as-needed basis. BMPs and the conditions where they may be useful will be discussed during personnel training.

4.2.1 Berms

Berms are low barriers used to direct flowing water in a desired direction, away from its natural course. Although the use of berms to contain water within work areas is infeasible due to interference with mining activities, as described in Section 3.1.3, berms may be useful in areas of the mine where active mining and hauling is not occurring. Berms may be considered a potential water management practice in areas where they will not interfere with mining.

4.2.2 Channels

Channels are shallow watercourses, usually along roadways, in the mine. Although allowing water to flow uncovered in channels has been identified as a source of water quality degradation, there may be situations where construction of channels will be useful. For example, as with berms described above, channels may be useful in diverting flow away from main mine water sumps towards unused or inactive areas of the mine. In such situations, a simple open channel might be used or a combination of channel and pipe may be used, where the diverted flow has to cross a roadway.

4.2.3 Collection/Containment

Collection or containment may be used, where feasible and cost-effective, in situations where water impacted by mining activities is in proximity to sources of relatively unimpacted water. Possible collection/containment techniques may include:

- Construction of a local sump to collect the impacted mine water or the unimpacted water source for pumping.
- Use of diversion channels or berms to direct the flow of impacted mine water away from the source of unimpacted water.

The appropriate method of collection or containment will be determined on a case-by-case basis. In situations where the unimpacted water source is a newly discovered corehole, the procedure for evaluating corehole sealing will be followed.

4.2.4 Clean Mining Areas/Material Handling and Storage

The ‘Clean Mining Areas’ and ‘Material Handling and Storage’ BMPs discussed in Sections 3.4.4 and 3.4.5 are combined here because they are closely related. This combined BMP refers to maintaining work areas in the vicinity of open mine water in such a way as to minimize the potential for water quality degradation. This is especially relevant to areas around sumps and around channels that have not been piped. Where possible, stockpiled materials such as ore and waste rock should be located to minimize impacts to water. Equipment should also be stored away from water where possible.

4.2.5 Roadway Maintenance

Roadways will be inspected on a regular basis by mine supervision personnel and any significant repairs will be documented. These inspections will be specifically directed at identifying roadway conditions that might contribute to water quality degradation including, but not necessarily limited to, the following:

- eroded sections of the roadway that are likely to contribute to the degradation of mine water quality (repaired by filling to an acceptable grade)
- broken or plugged drain pipes (repaired by replacing broken pipe or clearing plug)
- water entering from the back and falling onto the road causing erosion (repaired by suspended curtains of suitable material over the roadway to divert falling water to ditches)

It should be noted that there may be cases where a low point in a roadway exists because it is the low point of the mine tunnel and not necessarily due to erosion. In such cases, filling may create insufficient clearance between passing trucks and the back, so repair is not feasible. When appropriate, significant problems and repairs will be logged in the Doe Run Enterprise Task Management System (ETMS).

4.2.6 Maintenance Schedules

Maintenance related to underground water management at Sweetwater Mine will be performed on an as-needed basis. Regularly scheduled inspections may identify additional maintenance needs.

4.2.7 Sump Cleaning

Sumps will be inspected quarterly as part of the routine water management inspection program at Sweetwater Mine. Part of this inspection will be reading of depth soundings to monitor the level of accumulated solids in the sump. If it is logistically feasible, each major mine water sump at Sweetwater Mine (#2 sump, A-Area sump, and #5 sump) will be equipped with a sonar depth finder capable of measuring the depth to the sediment/water interface. If this equipment can be installed, initially, a decrease in water depth of 50% at a point in close proximity to the pumps will be used to trigger sump cleanout. This level of fill is based on the experience of mine personnel. As described below, each of the main mine water sumps will be sampled on a regular basis and these data will be evaluated along with the level of accumulated sediment to determine whether a different level should be used to trigger sump cleaning. A standard operating procedure for monitoring sediment levels in main mine water sumps is included in Appendix C.

4.3 MONITORING

Ongoing underground water quality monitoring will be continued at the Sweetwater Mine to improve the understanding of mine water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 4-1 will be sampled, unless it is determined by Doe Run that an adequate amount of data has been collected.

Table 4-1. Underground Water Sampling Locations for the Sweetwater Mine.

Location	Sample ID Previously Used	Rationale
#2 Sump influent	SW-2 Sump WI; SW-2 Sump SI	Characterize water quality entering sump
#2 Sump near pumps	SW-2SUMPEFF	Characterize water quality leaving sump
A-Area sump influent	SW-ASUMPINF	Characterize water quality entering sump
A-Area sump near pumps	SW-ASUMPEFF	Characterize water quality leaving sump
#5 Sump influent	SW-5SUMPINF	Characterize water quality entering sump
#5 Sump near pumps	SW-5SUMPEFF	Characterize water quality leaving sump
CDH7	SW-CDH7	Characterize flows entering at CDH7

Continued monitoring was initiated in January 2012, and has typically been conducted on a monthly basis. The results of the continued monitoring efforts are presented in Figures 4-1 through 4-5. Evaluation of the most recent data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

In addition to the monitoring regime described above, supplemental monitoring may be performed to evaluate various water management measures, in order to evaluate effectiveness of the measures and to inform the adaptive management process for underground water management at Sweetwater Mine.

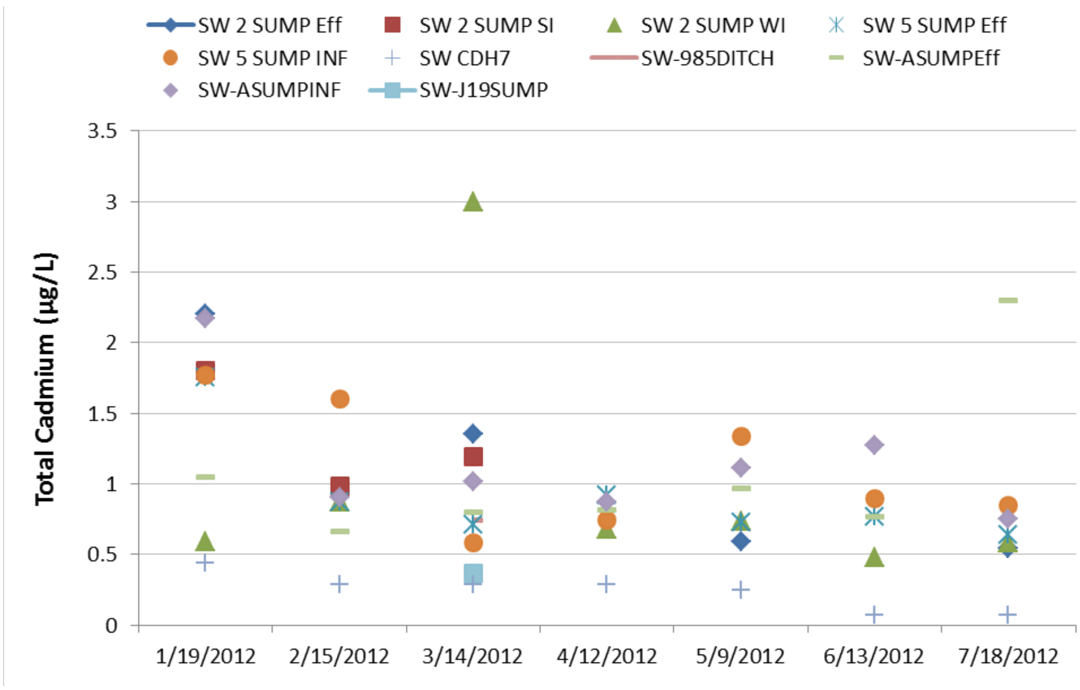


Figure 4-1. Continued Monitoring of Total Cadmium in Underground Sampling Locations at Sweetwater Mine.

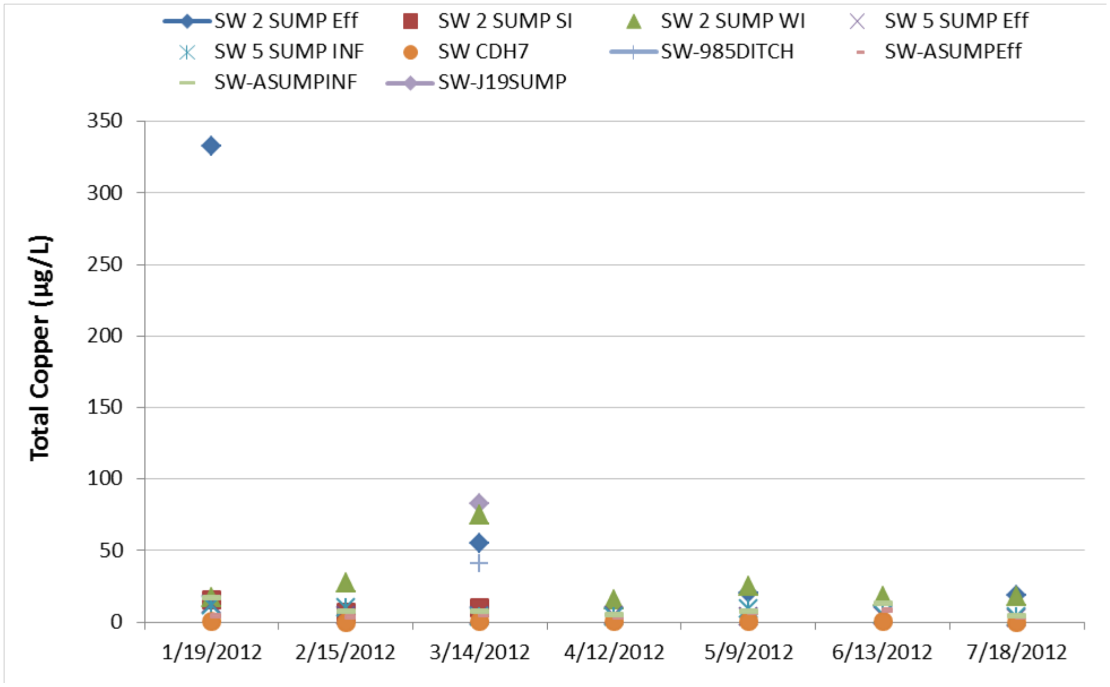


Figure 4-2. Continued Monitoring of Total Copper in Underground Sampling Locations at Sweetwater Mine.

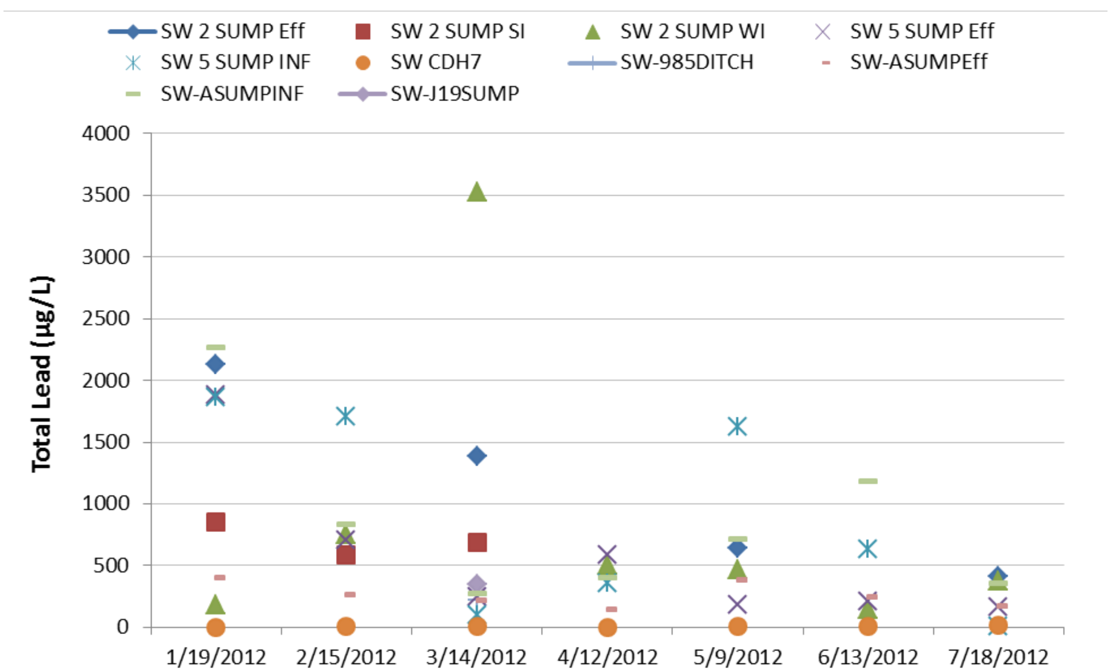


Figure 4-3. Continued Monitoring of Total Lead in Underground Sampling Locations at Sweetwater Mine.

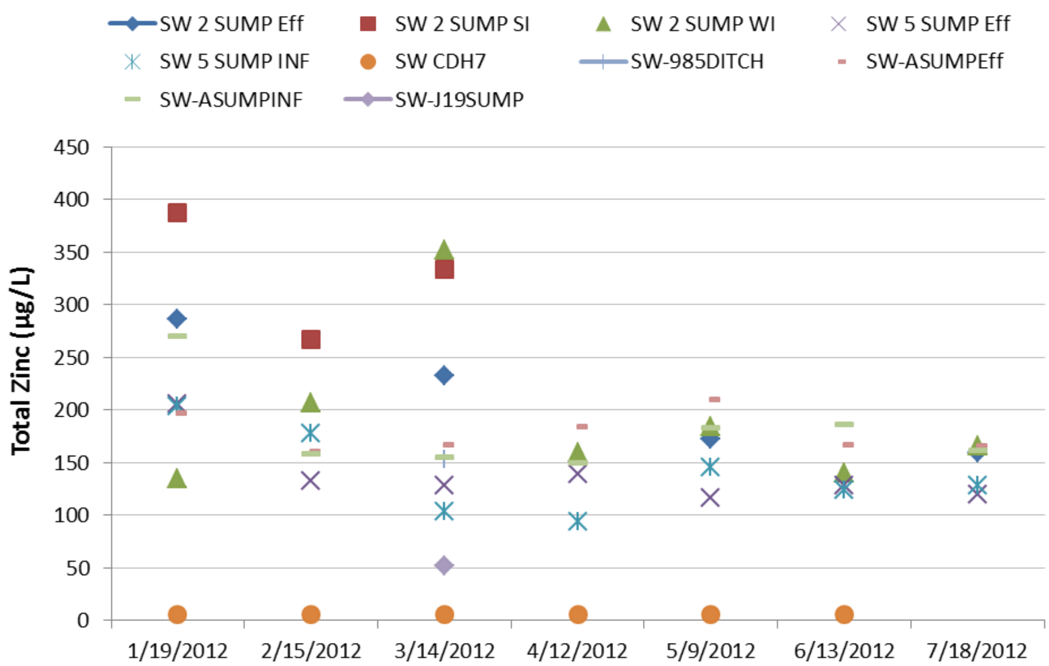


Figure 4-4. Continued Monitoring of Total Zinc in Underground Sampling Locations at Sweetwater Mine.

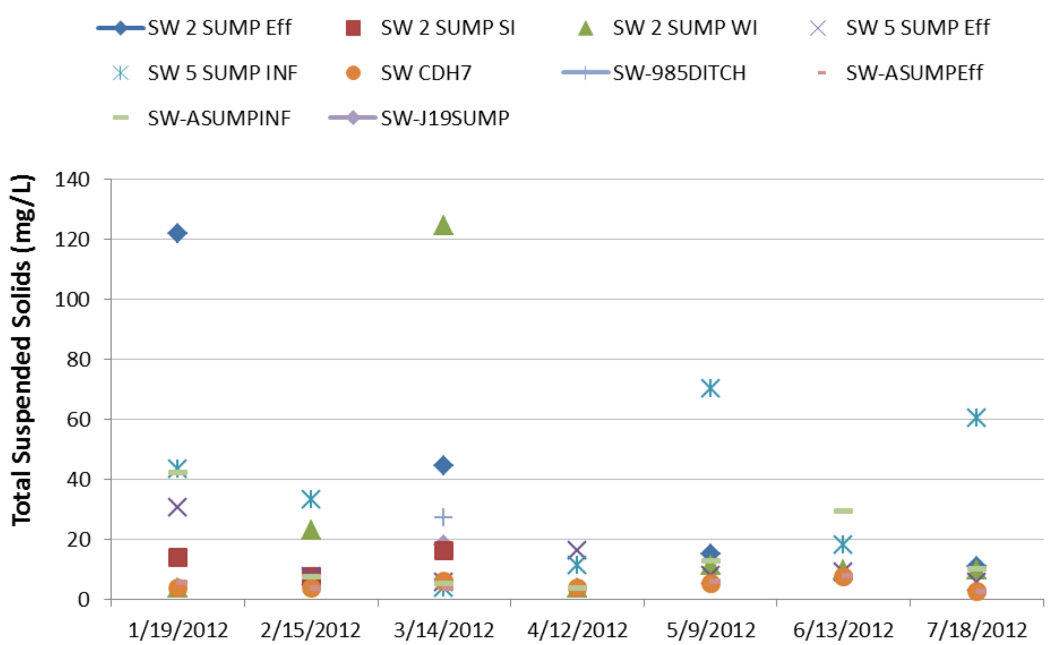


Figure 4-5. Continued Monitoring of Total Suspended Solids in Underground Sampling Locations at Sweetwater Mine.

4.4 INSPECTIONS

Underground water management inspections will be conducted at Sweetwater Mine on a quarterly basis to monitor effectiveness of water management measures and to identify the need for maintenance. Inspections will include visual inspection of the following:

- Main mine water sumps, including #2 Sump, A-Area sump, and #5 Sump, to visually assess turbidity and general condition;
- Water piping, to identify leaks;
- Roadways, to identify the need for maintenance;
- Material and equipment storage areas to identify the need for improved separation from sources, conveyances, and sumps;
- Coreholes and/or fractures scheduled for sealing between the previous and current inspections, to verify that sealing has occurred and was effective;
- Sources of water identified since the previous inspection; and
- Any other water management actions undertaken since the last inspection.

Inspections will be conducted by trained personnel (see Section 4.5). All inspections will be documented using the form in Appendix D, which will include the name and signature of the person performing the inspection.

4.5 TRAINING

Training was identified in the Master Underground Water Management Plan and will be an important part of the plan for Sweetwater Mine. Initial training will be provided by March 31, 2012 to all personnel involved in the management of water at Sweetwater Mine including, but not necessarily limited to:

- Mine supervision
- Mine engineers
- Technical service personnel
- Environmental technicians

In addition to the initial training for these personnel, annual refresher training will be conducted.

The purpose of the training will be to educate personnel in the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for underground water management (including the environmental need);
- Best management practices to be used throughout the mine;
- Specific water management actions being implemented or planned;

- Water management protocols and standard operating procedures;
- Inspections;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

4.6 TRACKING/RECORD-KEEPING

Water management measures will be inspected at Sweetwater Mine quarterly and the inspections will be documented on the form included in Appendix D. These forms will be kept on file on-site by the Sweetwater Underground Water Manager or designee. In addition, all significant water management measures and best management practices implemented at Sweetwater Mine will be documented in writing and a copy kept on file at the same location. Actions taken, best management practices, inspections, and maintenance of underground water management measures will be recorded in the Doe Run ETMS.

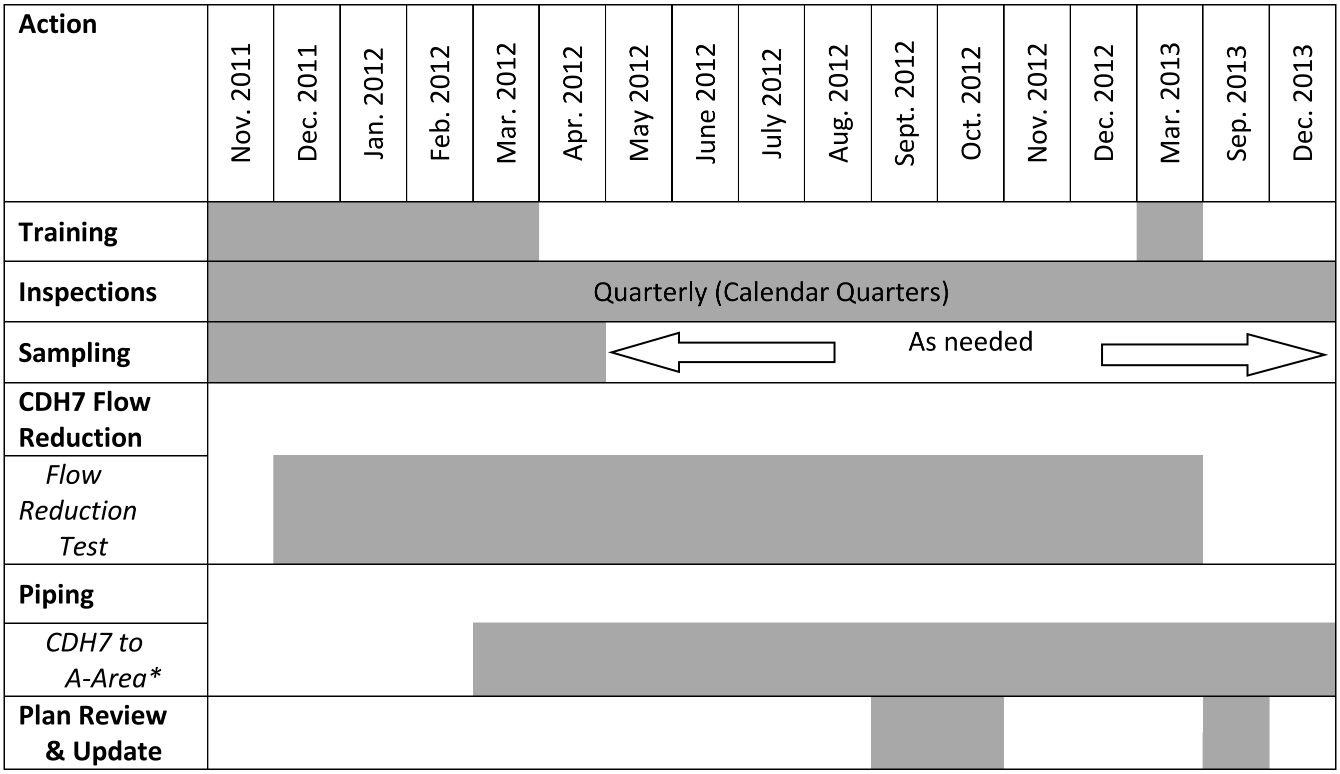
4.7 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between September 1 and October 31, 2012. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Sweetwater Mine/Mill facility.

4.8 IMPLEMENTATION SCHEDULE

The current schedule for the water management plan implementation is presented in Table 4-2. This schedule is based on the best information available as of the date of this plan.

Table 4-2. Current Implementation Schedule for Underground Water Management Plan Activities at Sweetwater Mine.



* Doe Run notes that the piping project is impacted and dependent on the outcome of the CDH7 Flow Reduction project. In August 2012, Doe Run began a grout feasibility analysis in lieu of the pumping test described in the previous UWMP. This analysis included drilling a series of test holes to observe the conditions in the immediate area of the shaft to determine if chemical grout could be used to block the inflow of the water into the water conduit of the shaft. After completion of this analysis, Doe Run determined that the chemical grouting is not the best option for reducing flow at this time. Other potentially effective alternatives for eliminating flow from CDH7 are currently being explored. Given this delay, the Flow Reduction Test is now expected to complete by March of 2013.

This page is blank to facilitate double sided printing.

5. REFERENCES

LimnoTech. Underground Water Sampling and Analysis Plan Report. August 4, 2011. (LimnoTech, 2011)

Resource Environmental Management Consultants, Inc. *Master Underground Water Management Plan: The Doe Run Company SEMO Operations*. 2010. (RMC, 2010)

U.S. Geological Survey. “History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict” (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008)

This page is blank to facilitate double sided printing.

APPENDIX A:

SWEETWATER MINE WATER FLOW MAP WITH LEAD AND ZINC SAMPLING RESULTS

This page is blank to facilitate double sided printing.

LAST UPDATE AUGUST_2011

APPENDIX B:

VENDOR INFORMATION ON GROUT USED FOR COREHOLE SEALING

This page is blank to facilitate double sided printing.

CHEMICAL GROUTING SPECIALISTS

STI 03 - 0.03

H20STOP

Dual component, low density, highly reactive, early strength, water control grout

Uses

Water control in mining and civil applications for cessations of high (3,000 G.P.M. +) leaks, combined with rapid void filling and early strength characteristics.

Advantages

- **Extremely fast reacting**
- **Rapid sealing**
- **High early strength**
- **Will inject into the finest of fractures**
- **Will not wash out**

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture. Store under 80 degrees.

Packaging

55 Gallon Steel Drums

Approvals – On file

Transport

USDOT Unregulated Class 55

Shelf Life

2 Year minimum in unopened containers.

Physical Properties

-20º F (shrinkage)	0% 1 day	ASTM D-2126
Viscosity @ 68º F	200 cps A – Side	300 cps B – Side
Specific Gravity @ 60º F	1.23 A - Side	1.04 B - Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Density (Free Rise)	03 PCF	ASTM D-1622
Compressive	200 psi	ASTM D-1621
Tensile	112 psi	ASTM D-638
Shear	107 psi	ASTM D-732

Sub-Technical, Inc.
363 Mars Valencia Road
Mars, Pennsylvania 16046 U.S.A.
Phone: (724)625-0008 Fax: (724)625-0009
www.sub-technical.com
stisales@sub-technical.com

Always Read MSDS Sheets Prior to USE

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

HYPERFLEX

Single component, low density, flexible, hydrophobic grout.

Uses

Sealing of water and gasses in mining and civil applications. Reacts with moisture to form a flexible closed cell grout.

Advantages

- **Simple application**
- **Adjustable set time with catalyst**
- **Flexible, absorbs movement**
- **Low expansive pressure**
- **"Self injection" into the finest of fractures**

Packaging

55 Gallon Steel Drums
5 Gallon Plastic Containers
5 Gallon Metal Containers
1 Gallon Metal Containers

Approvals

NSF 61-2007 approved for use with potable water.

Transport

USDOT. Unregulated Class 55

Physical Properties

Density	Free rise	2.25 lbs/ft³
Low temp. aging	Confirmed	
-20° F (shrinkage)	0% 1 Day	ASTM D-2126
Viscosity	4000 cps	ASTM D-2126
Specific Gravity @ 60° F	1-30%	A-Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Compressive	25 psi	ASTM D-1621
Shear	171 psi	ASTM C-273
Tensile	30 psi	ASTM D-1623
Elongation	300%	ASTM D-1623

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture.

Shelf Life

2 year minimum in unopened containers.

Caution: Always read MSDS prior to use.

WWW.Sub-Technichal.com

724 625 0008 VOICE 724 625 0009 Fax

APPENDIX C:

STANDARD OPERATING PROCEDURES

This page is blank to facilitate double sided printing.

I. INTRODUCTION

Mine water sumps provide temporary storage for mine water, which results in the settling of solids proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids. This means that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, the accumulated solids could eventually impede pumping. For these reasons, periodic maintenance of the sumps is required to remove accumulated solids.

The process of sump cleaning is referred to as "sump mucking". This involves draining the sump, then mechanically removing the accumulated solids from the sump. This standard operating procedure provides guidelines for monitoring main mine water sumps and determining the need for sump cleanout.

II. MATERIALS

The following materials will be available to monitor mine sumps:

- Personal protective equipment as required by the Health and Safety Plan;
- Light source;
- Depth finding device;
- Tape measure;
- Field log;

III. PROCEDURES / GUIDELINES

All major mine sumps will be cleaned when the accumulated solids exceed 50% of the water depth in the sump at the point of measurement near the pumps. To determine the sump mucking trigger, the following procedures must be adhered to:

A. Depth Measurement

1) A depth finding sonar device will be installed near the pumps at each of the major mine sumps to measure the depth of sediment in the sump.
2) A standard reference mark will be established for each sump, to which the water level can be referenced on a recurring basis.
3) The water level will be determined by measuring from the standard reference mark down to the water level with a tape measure.
4) As an alternative to steps 2 and 3, mine personnel may opt to install a staff gauge in the sump for measuring water level.

B. Inspection

1) During each quarterly inspection, the water level and depth to solids in each sump will be recorded from depth finding device.

C. Documentation

The following information will be recorded:

1) Sump identification/location
2) Sump inspection date
3) Measurement of water level
4) Measurement of depth to sediment in each sump
5) Notification of underground water management team, if the depth of solids is more than 50% of the water depth in the sump
6) Start and end date for sump cleanout and problems encountered

I. INTRODUCTION

Exploration coreholes at the Doe Run Mines are currently sealed by mine personnel. This practice has been in place for many years. New coreholes that are encountered during mining operations and that produce significant flows to the mine will be sealed, if sealing is technically feasible. This standard operating procedure provides a decision framework and guidelines for monitoring and sealing coreholes when they are encountered during mining operations.

II. MATERIALS

The following materials, as required, will be used when coreholes are encountered:

- Any necessary safety equipment;
- 55 gallon drum or other similarly sized container of known volume;
- 5 gallon bucket or similar smaller container;
- Stopwatch;
- Measuring tape;
- Field log;
- Mine map;
- Camera.

III. PROCEDURES / GUIDELINES

When a corehole is encountered during mining operations the following procedures shall be used:

A. Determine flow rate from corehole

1) Flowrate from the corehole will be estimated by measuring the time required to fill a 55 gallon drum or other similarly sized container of known volume.
2) If the location of the corehole prevents the use of a 55 gallon drum or if the flow is too small for filling of a 55-gallon drum to be practical, then a 5 gallon bucket or similar smaller container will be used.
3) If, due to the quantity of flow or for safety reasons, it is not possible to measure the flow, this should be reported to the underground water management team who will determine an alternate flow estimation method.
4) Because flows often change after coreholes are encountered, the flow rate will be measured once per month for three months to obtain a better estimate of its long-term flow.

B. Measure the corehole diameter

1) The diameter of the corehole will be measured to the nearest inch.
2) If it is infeasible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.

C. Determine if sealing is required and feasible

1) If the flow from the corehole exceeds 25 gallons per minute the corehole will be sealed.
2) The underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past.
3) If it is unclear whether sealing is feasible, the underground water management team will consult with manufacturer's representatives for mechanical plugs and grouts to help

determine the feasibility of sealing the corehole.

D. Seal the corehole

If it has been determined that the corehole can be sealed, the underground water management team will determine a schedule for the sealing work and ensure that the work is completed.

E. Documentation

The following information must be recorded in writing and submitted to the underground water manager:

1) Corehole discovery time and date.
2) Location of corehole recorded on map
3) Diameter of corehole
4) Measured flowrate – record procedure and results
5) Determination of sealing requirement
6) Problems encountered with sealing determination
7) Communication with the underground water management team
8) If the corehole cannot be sealed – record the reasons for that determination
9) Methods and procedures of corehole sealing
10) Problems encountered in the sealing process and apparent success
11) Sealing completion time and date.
12) Pictures of the corehole will also be taken and kept with the field log.

APPENDIX D:

UNDERGROUND WATER CONTROL MEASURE INSPECTION FORM

This page is blank to facilitate double sided printing.

Underground Water Management Inspection

Date: ______________________ **Inspection By:**_______________________

Mine: ____

Notes: ____

Sumps

Sump ID/Location	Water Level	Depth to Sediment	Notification Date

Notes: ____

____

____

Piping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

Underground Water Management Inspection

Date: ______________________ **Inspection By:**_______________________

Roadways

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

BMPs/General Housekeeping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

EXHIBIT J

UNDERGROUND WATER MANAGEMENT PLAN for the VIBURNUM 29 MINE

Prepared for: **The Doe Run Resources Corporation d/b/a The Doe Run Company**

December 2, 2011

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix A: Viburnum 29 Mine Water Flow Map with Lead and Zinc Sampling Results
Appendix B: Vendor Information on Grout Used for Corehole Sealing
Appendix C: Standard Operating Procedures
Appendix D: Underground Water Control Measure Inspection Form

1. INTRODUCTION

This document presents the Underground Water Management Plan (UGWMP) for the Viburnum 29 Mine, prepared on behalf of the Doe Run Resources Corporation, d/b/a/ The Doe Run Company (DRC). The Viburnum 29 UGWMP has been prepared in accordance with the Master UGWMP previously prepared by Resource Environmental Management Consultants, Inc. In keeping with the Master UGWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Viburnum 29 Mine is located in Washington County, Missouri, approximately 5 miles north of Casteel (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Viburnum 29 Mine (USGS, 2008).

Year	Event
1964	Production began with no mill or tailings pond onsite; ore trucked to the Central Mill for processing
1974	Mine water surface ponds constructed as settling basins for mine water and stormwater runoff
Ca. 1995	Ore trucked to the Buick Mill for processing
Ca. 2001	Mine closed; production ceased
2004	Mine reopened; production resumed

The Viburnum 29 Mine is the northernmost mine in the Viburnum Trend. Mining operations occur approximately 600 feet below ground surface.

1.2 OBJECTIVES

As stated above, the main objective of this UGWMP is to evaluate the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility. This main objective is met through the following:

- Understanding of the sources, quantity and movement of water through the mine.
- Understanding of the quality of water entering, moving through, and leaving the mine, with respect to the target constituents of interest.
- Identification and evaluation of potential control measures for reducing water volumes, metals concentrations, or both in the mine.

Each of these items is discussed in this plan. The UGWMP also presents an assessment of the technical feasibility of various potential control measures for the Viburnum 29 Mine, as well as a plan for further investigation or implementation of potentially technical feasible control measures, based on whether such measures are likely to reduce metals loading and whether they are cost-effective.

1.3 UNDERGROUND WATER MANAGEMENT TEAM

Underground water management for the Viburnum 29 Mine will be the responsibility of the individuals named in Table 1-2.

Table 1-2. Viburnum 29 Mine Underground Water Management Team.

Job Title	Name	Contact Information	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	P.O. Box 500 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mine Manager	Greg Sutton	P.O. Box 500 Viburnum, MO 65566 573-626-2001	Oversight and management of Doe Run Mining Operations
Viburnum 29 General Mine Supervisor	Allen Mercer	10774 Wells Road Steelville, MO 65565 573-244-8645	Primary Responsibility for Viburnum 29 UGWMP Oversight, Implementation, and Record-Keeping
Viburnum 29 Mine Superintendent	Ray Morgan	1382 Sweetwater Mine Rd Ellington, MO 63638 573-924-2222 ext. 2454	Secondary Responsibility for Viburnum 29 UGWMP Oversight, Implementation, and Record-Keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573-689-4535	Environmental data collection, management, and reporting

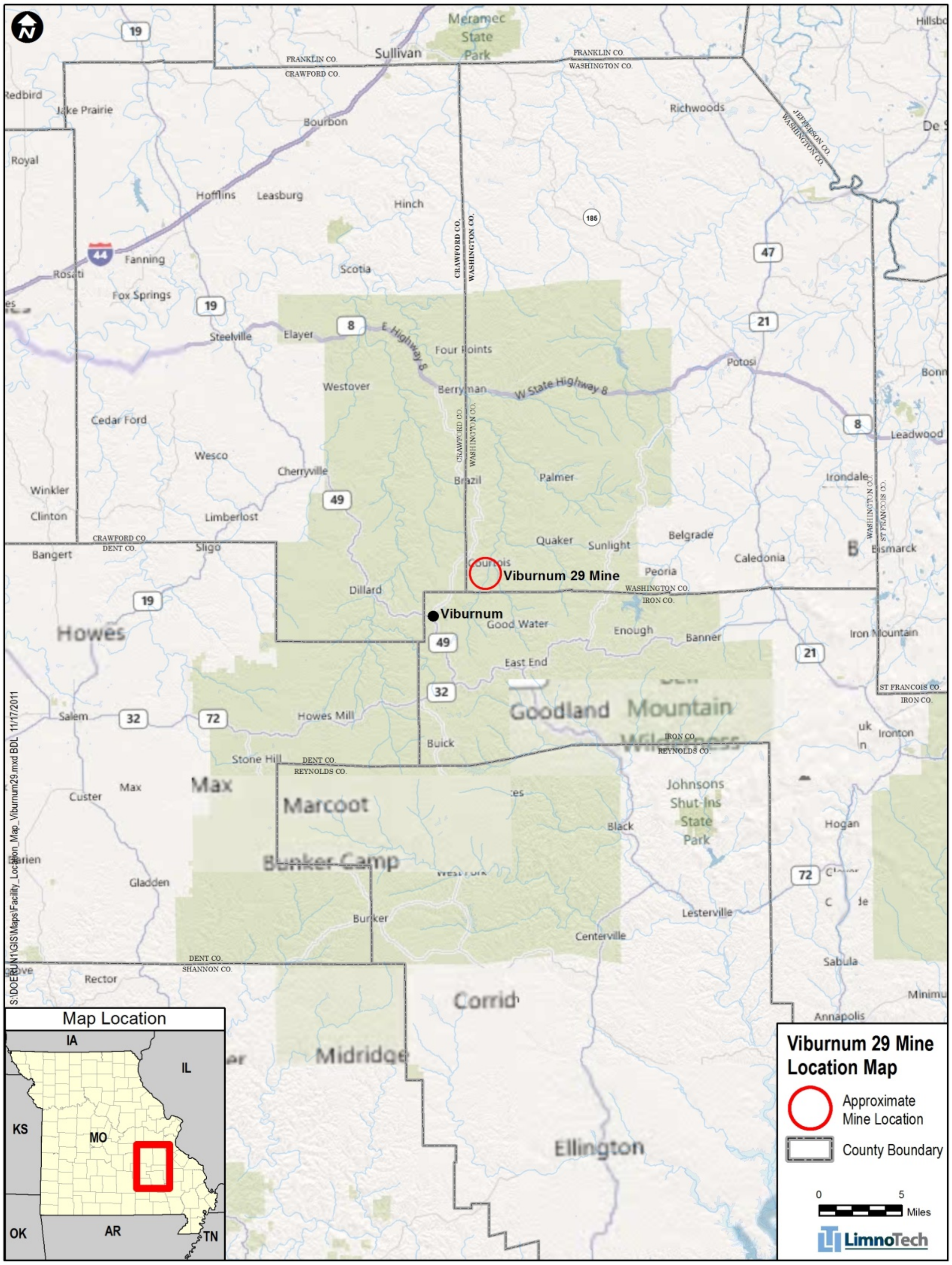


Figure 1-1. Location of the Viburnum 29 Mine.

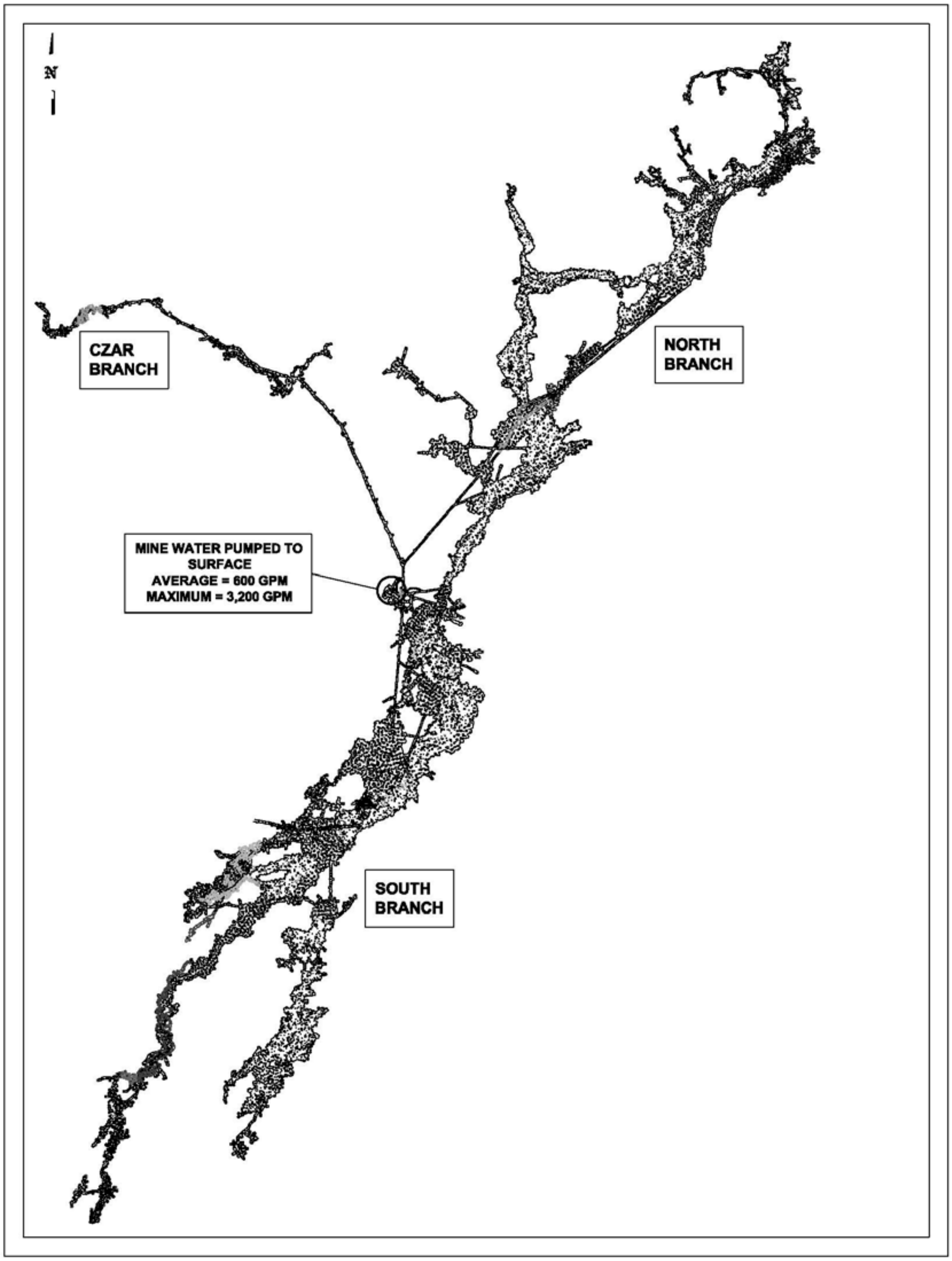


Figure 1-2. Layout of the Viburnum 29 Mine.

2. SUMMARY OF MINE WATER DATA

The Master UGWMP outlined the hierarchy of water management priorities listed below from highest priority to lowest.

1. Source Control
2. Water Minimization
3. Reuse or Reclamation
4. Water Treatment
5. Discharge

Because source control has been identified as the first water management priority, source identification is a fundamental part of the planning effort for potential measures to control metals loading. Load is a function of both flow and concentration; therefore, these components were each examined independently at the Viburnum 29 Mine, as described below.

2.1 WATER SOURCES AND MOVEMENT

An inventory of water in the Viburnum 29 Mine was compiled for this plan based on the best available information and includes the following components:

- Total mine water flows
- Sources of mine water
- Current underground management of mine water

Each of these components is described below.

2.1.1 Total Mine Water Flows

Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Viburnum 29 Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-1.

Table 2-1. Mine Water Flowrates at Viburnum 29 Mine.

Quantity	Value
Average Flow Pumped to Surface	600 gpm
Maximum Mine Water Pumping Capacity	3,200 gpm

Flow data are not currently recorded at the mine water sump, but flow is metered and instantaneous flow measurements can be read from the meter. The average flow reported in Table 2-1 is based on historical data and the maximum pumping capacity is based on pump capacity but does not reflect maximum flows actually pumped from the mine. It is known that flow rate can vary over time depending on factors such as season or where the mine is being advanced, however the values in Table 2-1 represent the best available estimate.

2.1.2 Sources of Mine Water

Water enters the Viburnum 29 Mine mainly through shafts and general seepage. In addition to vent shafts, a shaft called the "road rock hole" is located near the main mine water sump. This road rock hole was drilled to allow crushed rock to be poured into the mine for road maintenance. Given the diffuse nature of most water entering the mine it is difficult, if not impossible, to accurately measure all sources. However, mine water flows were measured at some key locations during the preparation of this plan to better understand the distribution of flows in the Viburnum 29 Mine. The major flow distribution is as follows:

- The measured flow from the Czar Branch is approximately 30 gpm.
- The measured flow from the road rock hole is 220 gpm.
- The measured flow from the south branch drift (not including flow from open stopes) is approximately 100 gpm.
- The flow from the north branch is approximately 150 gpm, as estimated by Doe Run Technical Services.
- The remaining portion of the 600 gpm of average mine water flows come from the south end of the mine (approximately 100 gpm).

This flow distribution is depicted schematically in Figure 2-1.

2.1.3 Current Underground Water Management Practices

Current practices to manage mine water at Viburnum 29 Mine are primarily focused on maintaining safe and workable conditions in the mine and are not specifically designed to maintain or improve water quality. These practices include the following:

- Piping – Piping of water through the mine has historically been performed to facilitate transfer pumping from one location to another, where mine grades prevent gravity flow. Piping is discussed in greater detail in Section 3.1.1.
- Sump cleaning – Sump cleaning, or mucking as it is called by mine personnel, has historically been performed as needed to maintain performance of the mine water sump pumps. Sump mucking is discussed in greater detail in Section 3.4.9.

Although it may not be their specific intent, these practices may have an incidental benefit of protecting water quality. These and other potential water management practices to preserve or improve water quality are discussed in greater detail in Section 3 of this Plan.

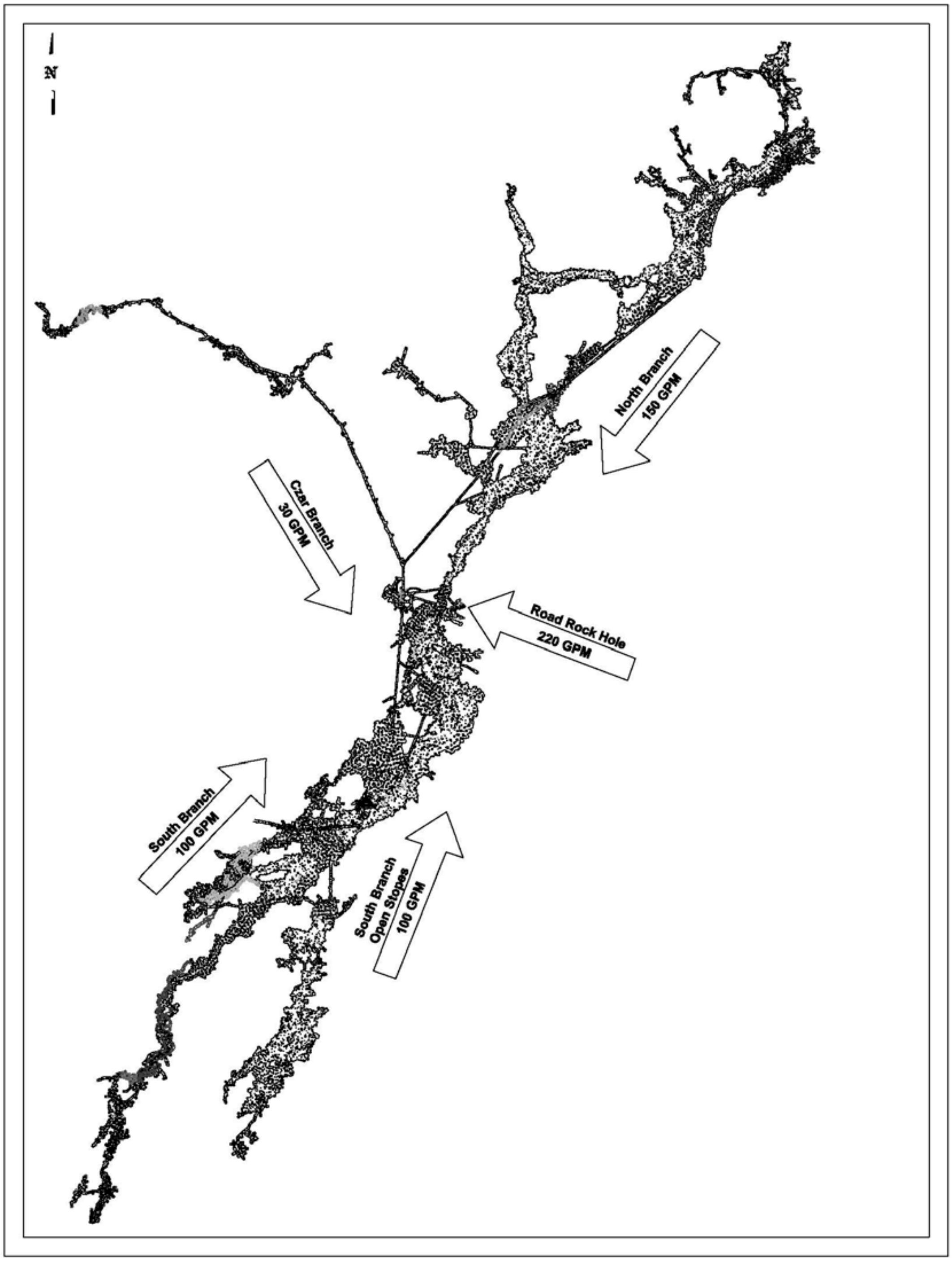


Figure 2-1. Major Mine Water Flows for the Viburnum 29 Mine.

2.2 MINE WATER QUALITY

To support development of this and other water management plans at Doe Run mine/mill facilities, a water quality sampling program was implemented between December 2010 and June 2011. Three rounds of underground water sampling were performed at each mine. The details of the underground sampling program, including the sampling results, are presented in the Underground Water Sampling and Analysis Plan Report (LimnoTech, August 4, 2011). A map of Viburnum 29 Mine showing sample locations, water flow paths, pump information, and sampling results for total and dissolved lead and zinc, is included as Appendix A.

To support preparation of this specific plan, supplemental mine water sampling was conducted on November 3, 2011. The results of this sampling effort are summarized in Table 2-3. Sample locations are shown in Figure 2-2.

Table 2-2. Supplemental Mine Water Sampling Results for the Viburnum 29 Mine/Mill Facility (all results in μg/L).

Sample ID	Tot-Cd	Diss-Cd	Tot-Cu	Diss-Cu	Tot-Pb	Diss-Pb	Tot-Zn	Diss-Zn	TSS
VIB-BISDIS	0.51	0.34	1.4	1.1	296	67.7	344	312	<5.0
VIB-CDH64CH	<0.50	<0.50	0.6	0.42	3.2	1.7	9.6	8.9	<5.0
VIB-CZAR1DIS	<0.50	<0.50	123	26.2	217	39	11.3	8.6	10.0
VIB-CZAR5BOX	<0.50	<0.50	42.5	27.3	326	64.4	13.4	16.5	7.0
VIB-NPB	<0.50	<0.50	20.8	10.4	624	79.1	25.6	29.9	13.0
VIB-PB87V1/V15	0.74	0.6	1.4	0.97	82.8	56.7	268	240	<5.0
VIB-PB87V1/V152	0.85	0.76	1.5	1.3	83.5	63.9	272	285	<5.0
VIB-RDRKH	<0.50	<0.50	1.1	0.69	5.6	1.5	2.8	8.5	6.0

These data were evaluated to better understand mine water quality at Viburnum 29 Mine and to discern factors that may improve or degrade mine water quality. Because the purpose of this UGWMP and the surface water management plan at Viburnum 29 is to be part of a comprehensive effort above and below ground to attain compliance with Missouri State Operating Permit (MSOP) future final limits for the discharge of mine water and other sources to waters of the State, the mine water data were evaluated in reference to the future final discharge limits in the MSOP for the Viburnum 29 Mine. The future final limits for the primary constituents of interest are summarized in Table 2-4 below.

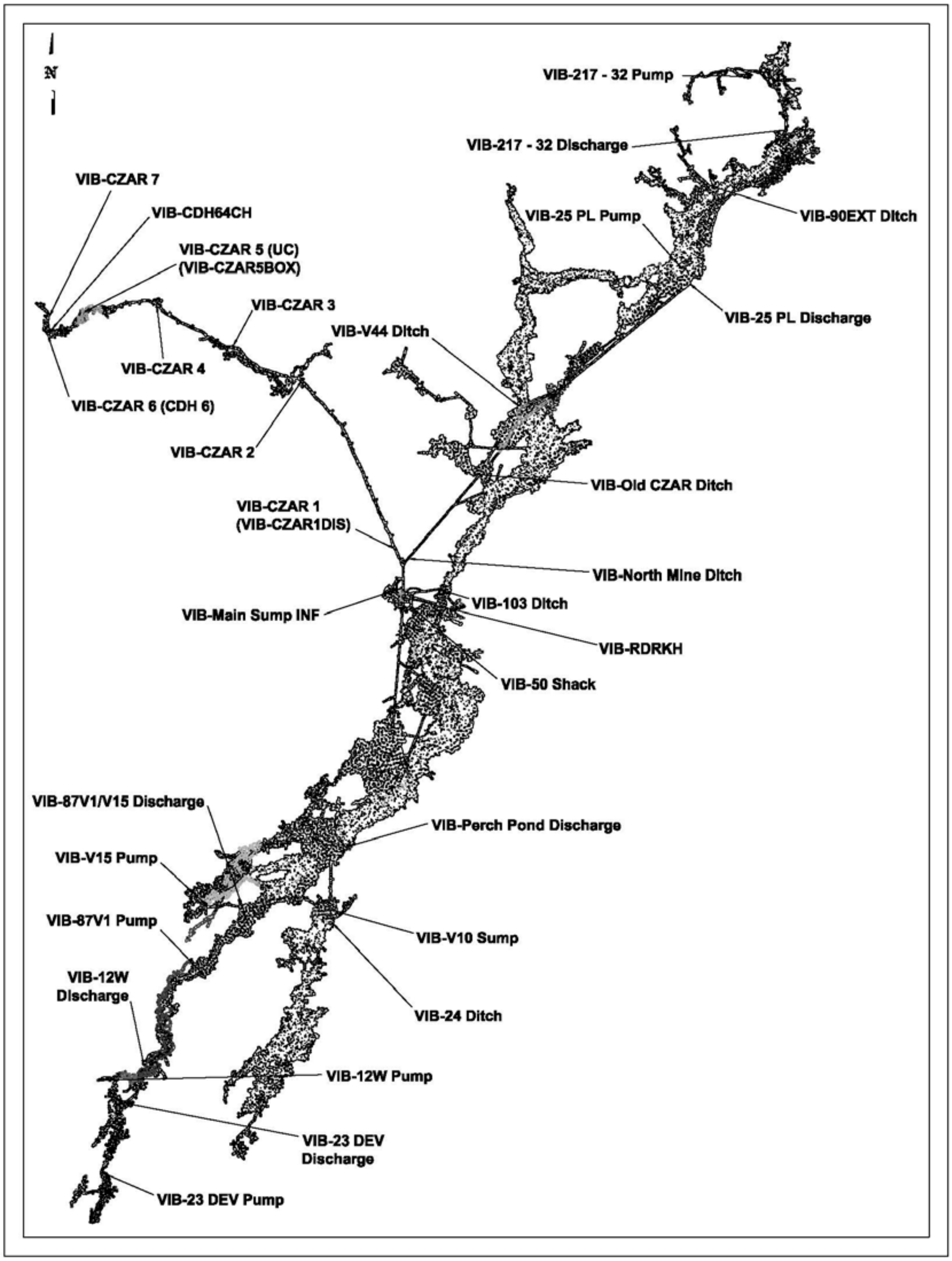


Figure 2-2. Mine Water Sampling Locations for the Viburnum 29 Mine.

Table 2-3. Future Final MSOP Limits for the Viburnum 29 Mine/Mill Facility (Outfall 004).

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	0.9	0.5
Copper, total recoverable	99.5	49.6
Lead, total recoverable	23.0	11.5
Zinc, total recoverable	322.5	160.7

The findings of this evaluation are presented in the following sections.

2.2.1 Incoming Mine Water Quality

Incoming mine water quality at Viburnum 29 Mine is characterized by samples collected at locations CZAR 6 (CHD6) and CZAR 7, which represent the inactive face at west terminus of the Czar stope area and the drill hole water at west end of Czar Stope, respectively. Two samples were taken from CZAR 6 (CDH6) and one from CZAR 7 during the underground water sampling program and the data are presented in Table 2-5. In addition, samples were collected recently at the road rock hole near the main sump (RDRKH) and at vent shaft CDH64, near CZAR 6. These results are also presented in Table 2-5.

Table 2-4. Incoming Mine Water Quality at Viburnum 29 Mine.

Location	Sampling Date	Parameter				
		Total Cadmium (μg/L)	Total Copper (μg/L)	Total Lead (μg/L)	Total Zinc (μg/L)	TSS (mg/L)
CZAR 6 (CDH6)	3-17-11	ND (0.08)[1]	24.2	41.8	ND (5)	ND (5)
CZAR 6 (CDH6)	6-8-11	ND (0.1)	42.0	96.0	2.5	3.0
CZAR 7	3-17-11	ND (0.08)	1.5	0.9	ND (5)	ND (5)
RDRKH	11-3-11	ND (0.50)	1.1	5.6	2.8	6.0
CDH64	11-3-11	ND (0.50)	0.6	3.2	9.6	ND (5)

[1] ND indicates that the parameter was not detected at the analytical detection limit shown in parentheses.

Comparing these results to the future final discharge limits presented in Table 2-3 shows that, in general, concentrations of primary metals in incoming mine water are well below the permitted future final discharge limits. The only exceptions are lead concentrations at CZAR6 (CDH 6), however these samples were collected after the incoming water had collected in a pool on the floor of the mine and the elevated lead is likely caused by that exposure to the workings. It is expected that incoming mine water at other locations has quality similar to CZAR 7, RDRKH, and CDH64.

2.2.2 Comparison of Incoming and Outgoing Mine Water

Inspection of the water data collected throughout Viburnum 29 Mine shows that samples at many locations contain concentrations of target metals above the permitted future final effluent limits, so incoming and outgoing mine water (i.e., mine water pumped to the surface) were compared to discern which of those metals exceed their respective future final discharge limits. These comparisons of samples taken of incoming mine water at CZAR 6 (CDH 6), CZAR 7, RDRKH, and CDH64 with mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-2, 2-3, 2-4, and 2-5, respectively.

As stated above, incoming mine water quality is characterized by samples collected at CZAR 6 (CDH 6), CZAR 7, RDRKH, and CDH64. Outgoing mine water is characterized by samples collected at Main Sump INF. A total of three samples and one duplicate sample (denoted with a “9” in the figures) were collected at this location in the 2011 underground sampling program.

The comparison of incoming and outgoing mine water shows that incoming mine water, at least in the samples collected at CZAR 6 (CDH 6), CZAR 7, RDRKH, and CDH64, is not expected to exceed the future final effluent limits (both daily maximum and monthly average) for cadmium, copper, or zinc but does for lead at CZAR 6 (CDH6). Mine water pumped to the surface, does not exceed these limits set for copper but does for cadmium, lead, and zinc. This indicates that, in general, metals concentrations in mine water increase as the water is exposed to the mine workings, with the exception of copper. The relationship between increased metals concentrations and increased suspended solids in mine water is discussed in Section 2.2.4 of this plan.

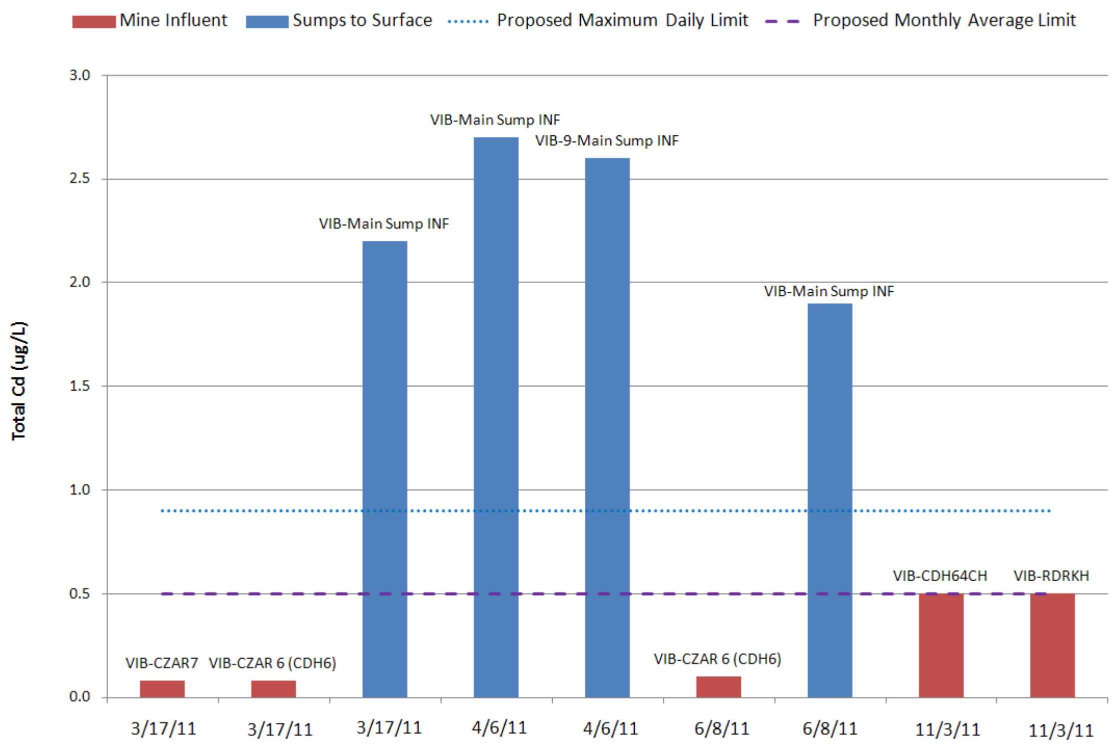


Figure 2-3. Incoming (CZAR7, CZAR6, CDH64, RDRKH) vs. Outgoing (Main Sump INF) Mine Water Quality at Viburnum 29 Mine: Total Cadmium.

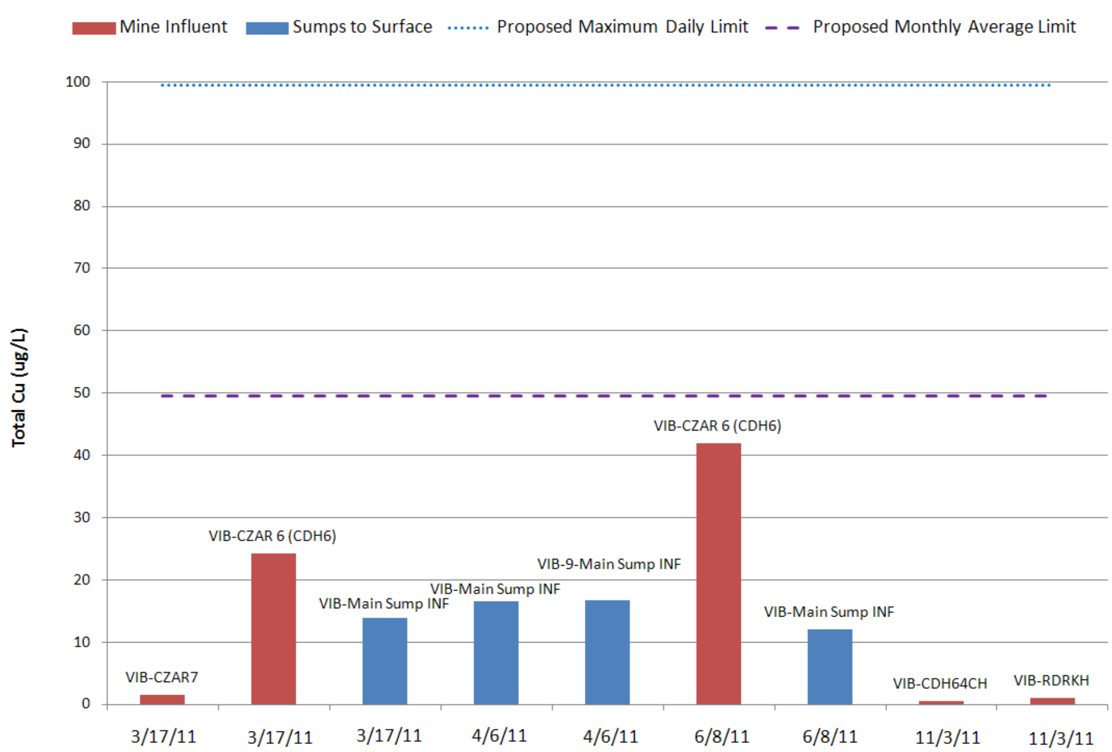


Figure 2-4. Incoming (CZAR7, CZAR6, CDH64, RDRKH) vs. Outgoing (Main Sump INF) Mine Water Quality at Viburnum 29 Mine: Total Copper.

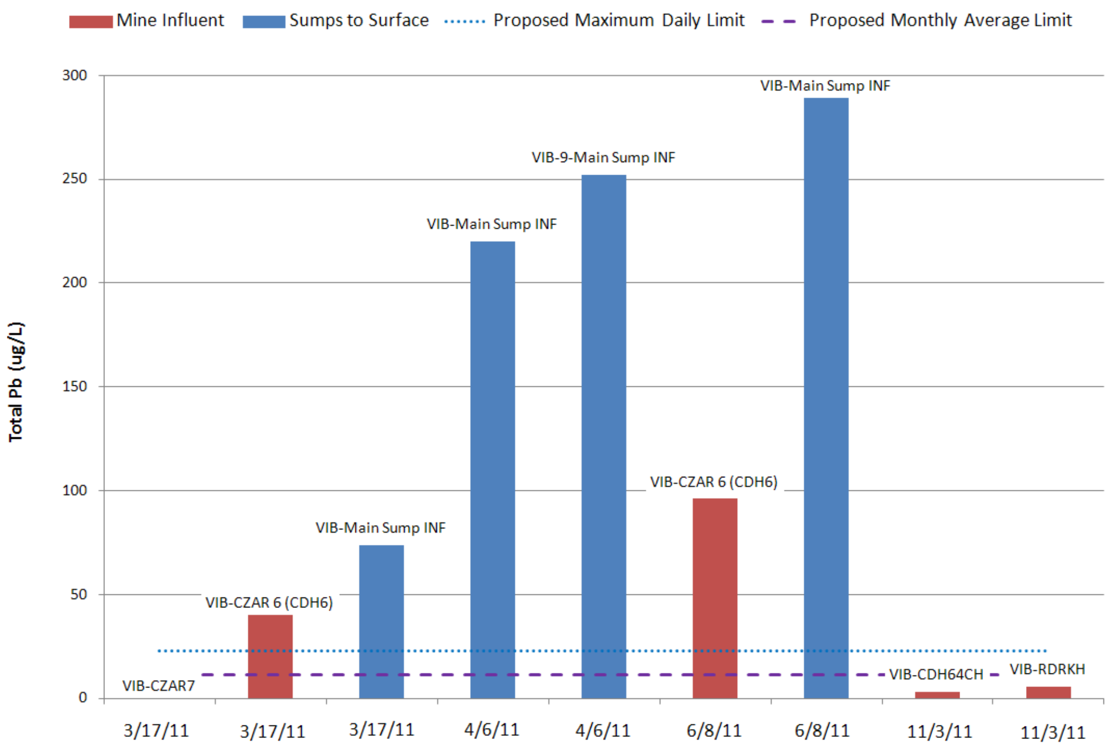


Figure 2-5. Incoming (CZAR7, CZAR6, CDH64, RDRKH) vs. Outgoing (Main Sump INF) Mine Water Quality at Viburnum 29 Mine: Total Lead.

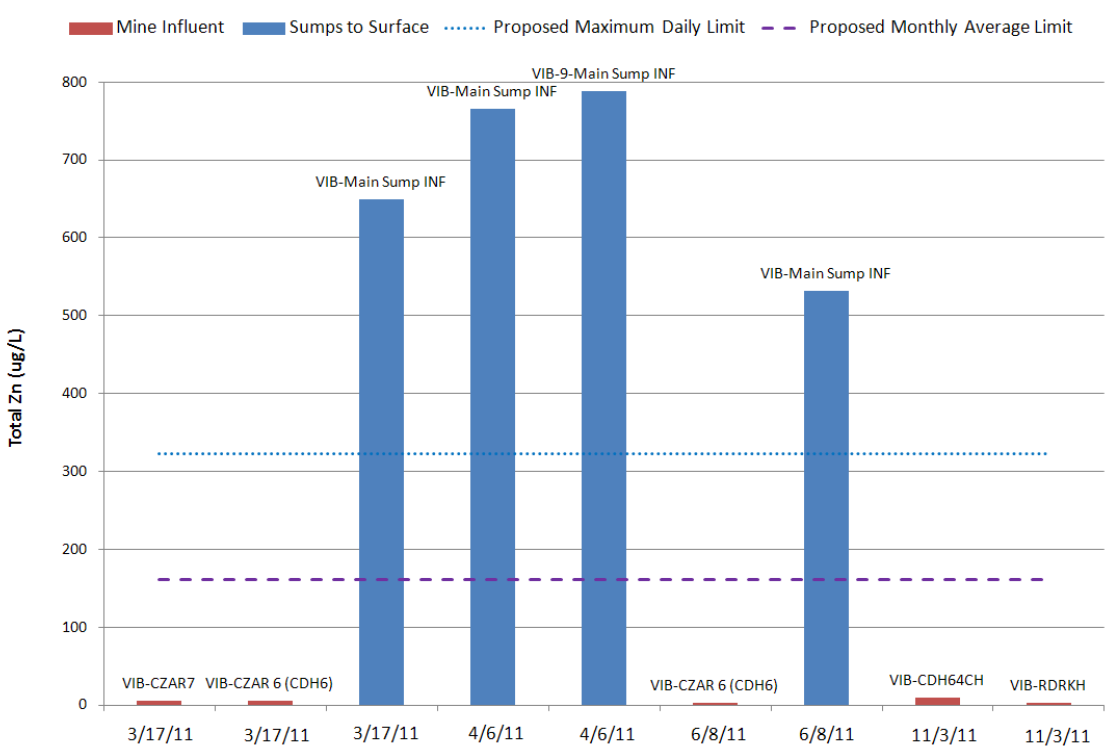


Figure 2-6. Incoming (CZAR7, CZAR6, CDH64, RDRKH) vs. Outgoing (Main Sump INF) Mine Water Quality at Viburnum 29 Mine: Total Zinc.

2.2.3 Spatial Variation in Mine Water Quality

The mine water sump in Viburnum 29 Mine is located between north, south, and czar (west) branches of the mine and, as shown in Figure 2-1, most of the mine water that is pumped to the surface comes from the south branch. However, although the south branch of the mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the three branches. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the three branches were compared. The results of this comparison are shown in Figures 2-7 through 2-10.

Figures 2-7 through 2-10 compare box plots of the mine water quality between the north, south, and Czar branches of Viburnum 29 mine. The box plots can be interpreted as follows:

- The dash in the center of each box represents the median value of the data set.
- The lower and upper edges of the box are the first and third quartiles (the first quartile represents the value that is equal to or greater than 25% of the data and the third quartile represents the value that is equal to or greater than 75% of the data), respectively.
- The lower and upper whiskers are the 5th and 95th percentile values.

For ease of comparison, each plot also shows the future final effluent limits for that metal in the MSOP. The following observations can be made from these plots:

- Cadmium: Cadmium tends to occur at slightly higher concentrations in the south branch than the north branch. The lowest concentrations of cadmium occur in the Czar branch. Overall, the range of cadmium concentrations in mine water spans the range of the daily maximum and monthly average future final effluent limits; some samples were slightly higher than the future final limits, some were lower. Almost all samples from the Czar branch were below both daily maximum and monthly average future final limits for cadmium.
- Copper: Copper tends to occur at higher concentrations in the Czar branch than both the north and south branches. The lowest copper concentrations are found in samples from the south branch. The range of copper concentrations spans two orders of magnitude and is below the range of the daily maximum and monthly average future final effluent limits in the north and south branches. Copper concentrations in the Czar branch tend to exceed the future final effluent limits.
- Lead: Concentrations of lead in mine water samples used in this comparison (which excludes incoming mine water) generally exceeded the daily maximum and monthly average future final effluent limits. Concentrations measured in the north and south branches were similar in magnitude; lead concentrations in the Czar branch were slightly higher than the other two branches.
- Zinc: Zinc tends to occur at higher concentrations in the south branch than in the north branch; concentrations in the Czar branch were lowest.

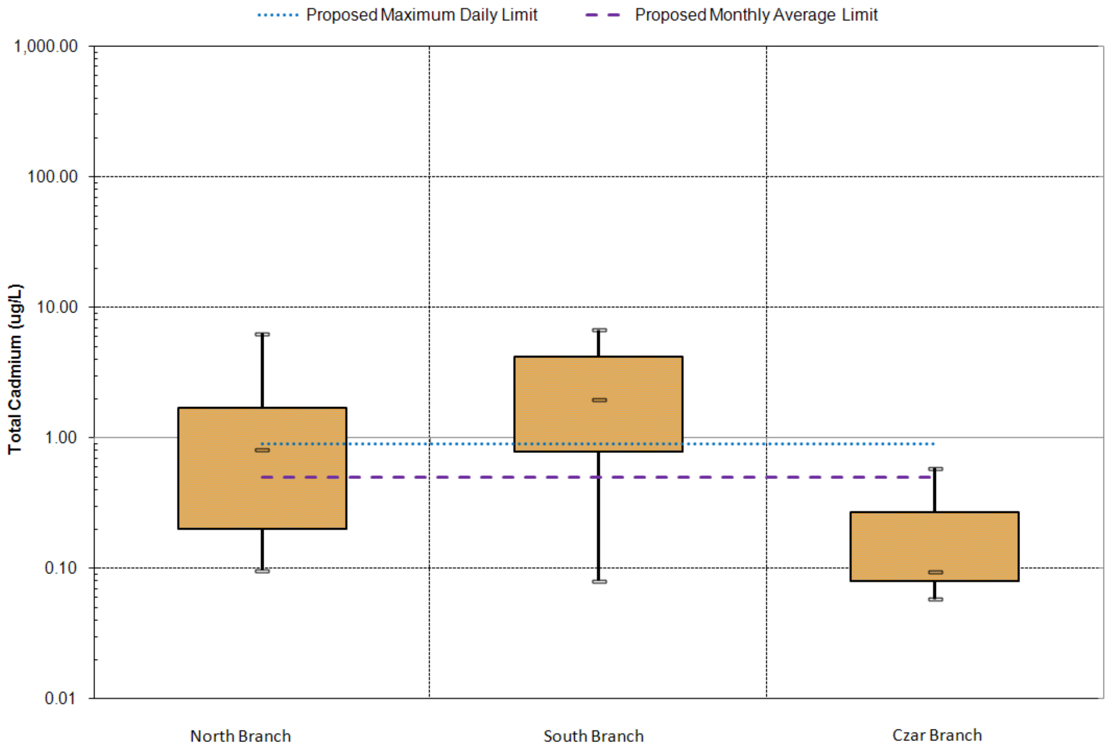


Figure 2-7. Comparison of Total Cadmium between North, South, and Czar Branches of Mine.

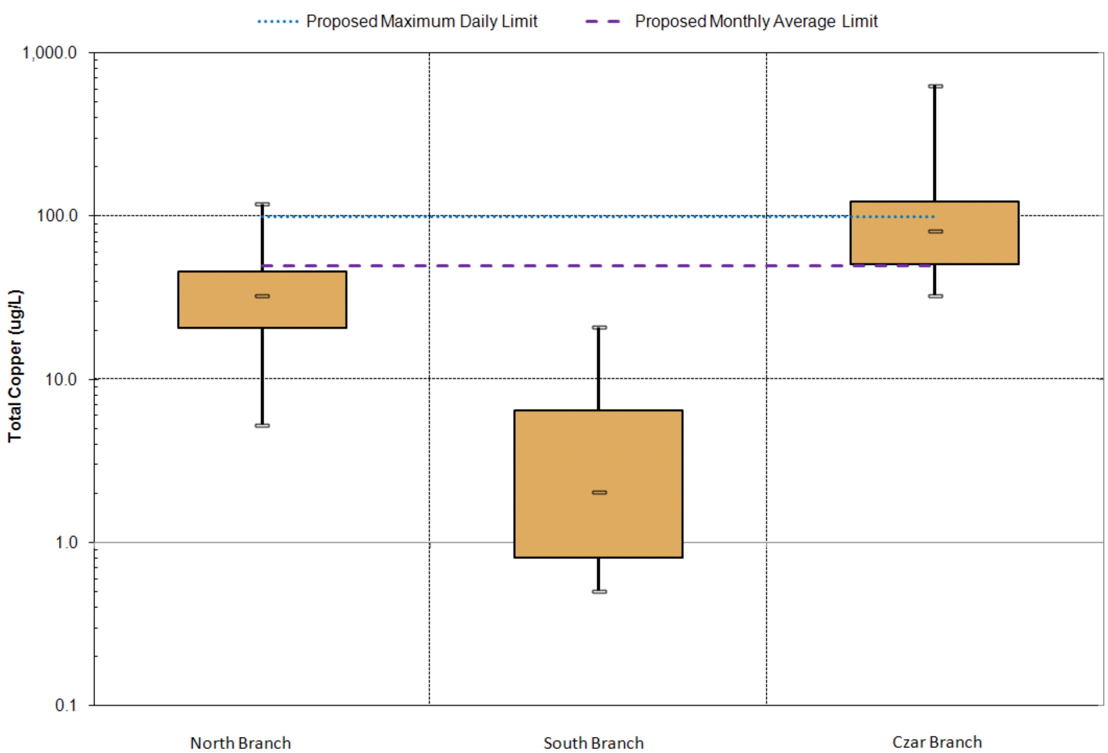


Figure 2-8. Comparison of Total Copper between North, South, and Czar Branches of Mine.

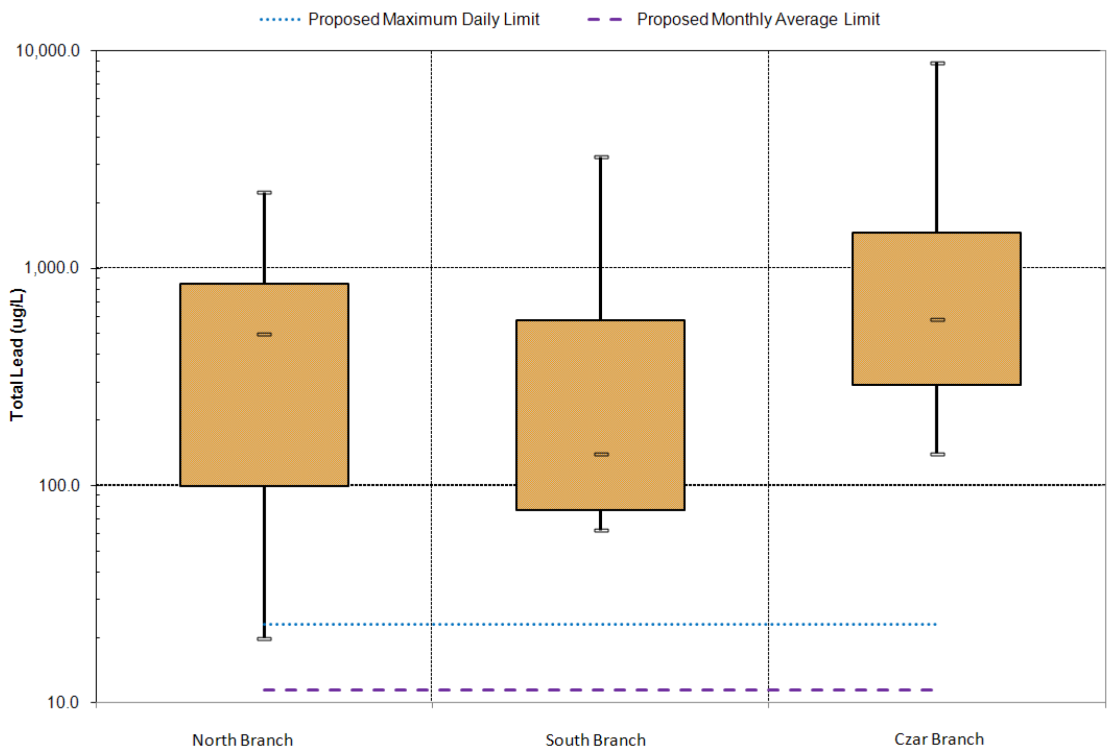


Figure 2-9. Comparison of Total Lead between North, South, and Czar Branches of Mine.

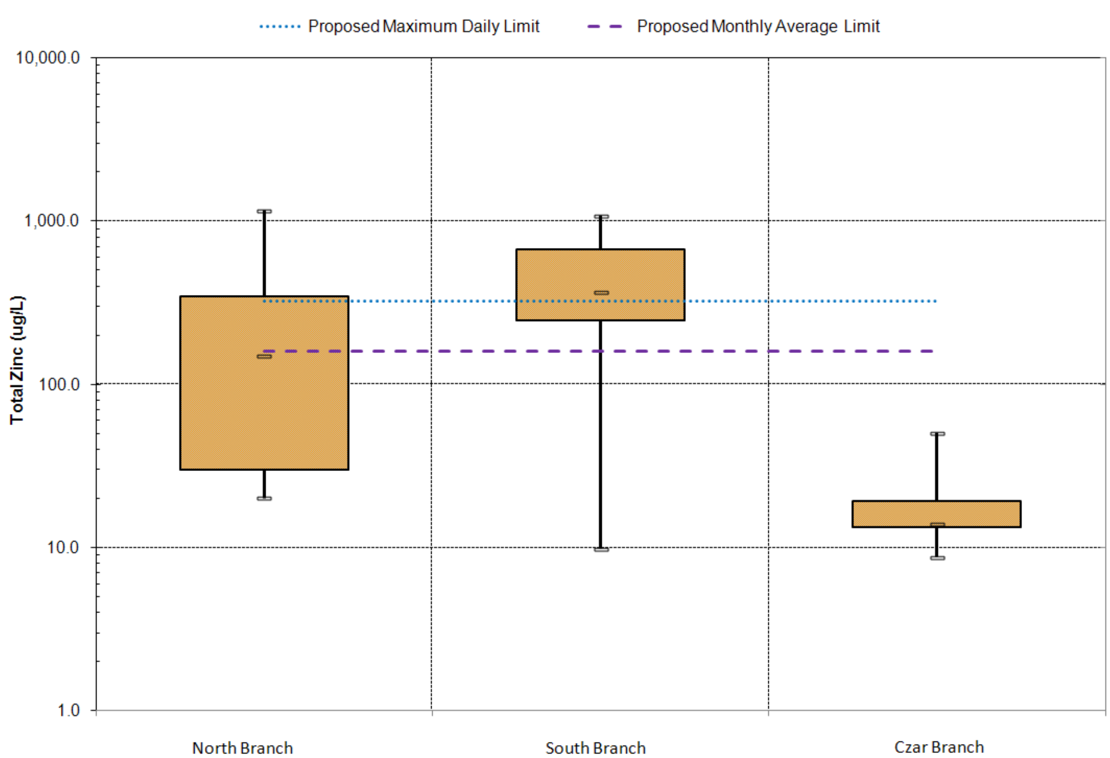


Figure 2-10. Comparison of Total Zinc between North, South, and Czar Branches of Mine.

Based on these comparisons, mine water in the three branches of Viburnum 29 Mine is not strongly differentiated with respect to cadmium and lead. However, there does appear to be a difference between the three branches with respect to copper and zinc concentrations. Copper is not necessarily of concern because copper concentration in mine water pumped to the surface is below future final effluent limits. However, the differences in zinc concentrations are worth noting. The median total zinc concentration in the south branch of the mine, for these data, was 368 μg/L compared to 150 μg/L for the north branch and 14 μg/L for the Czar branch (the future final monthly average effluent limit for zinc at Viburnum 29 is 160.7 μg/L). The maximum concentration was 1,550 μg/L in the south branch compared to 1,253 μg/L for the north branch and 80 μg/L for the Czar branch.

2.2.4 Relationship Between Solids and Metals in Mine Water

Data from Viburnum 29 Mine show that incoming mine water has relatively low metals concentrations compared to mine water that is pumped to the surface and that the concentrations are significantly increased by exposure to the mine workings (Section 2.2.2). Therefore, the Viburnum 29 Mine data were evaluated to assess the relationship between metals and suspended solids. Figures 2-11 through 2-14 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS).

These results show varying relationships of metals with TSS at Viburnum 29 mine. The correlations are summarized in Table 2-5.

Table 2-5. Correlations of Total Metals with Total Suspended Solids at Viburnum 29 Mine.

Parameter	Correlation with TSS (r^2 value)
Cadmium, Total	3.0E-7
Copper, Total	0.76
Lead, Total	0.79
Zinc, Total	0.005

The r-squared values[2] in Table 2-5 indicate that total copper and total lead are more closely correlated to TSS than cadmium or zinc. This suggests that increases in TSS, resulting from exposure of incoming mine water to mine workings, are a leading

[2] One way of interpreting r^2 values is that if total copper has an r^2 value of 0.76 with TSS, then TSS explains 76% of the variability of total copper in the data set.

contributor to increases in lead at Viburnum 29. TSS does not appear to strongly affect concentrations of cadmium or zinc.

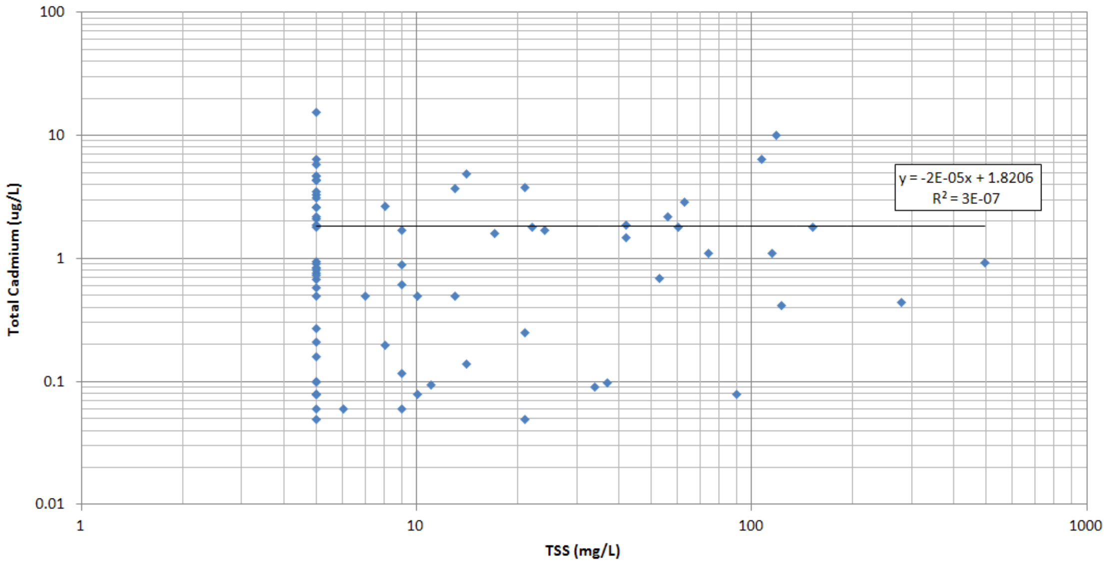


Figure 2-11. Correlation of Total Cadmium with Total Suspended Solids at Viburnum 29 Mine.

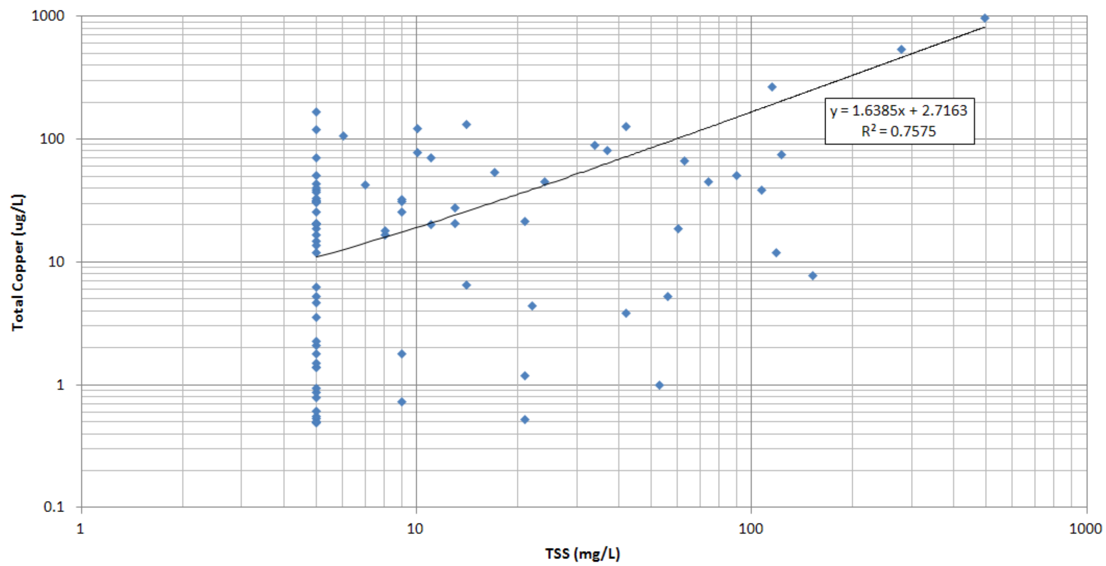


Figure 2-12. Correlation of Total Copper with Total Suspended Solids at Viburnum 29 Mine.

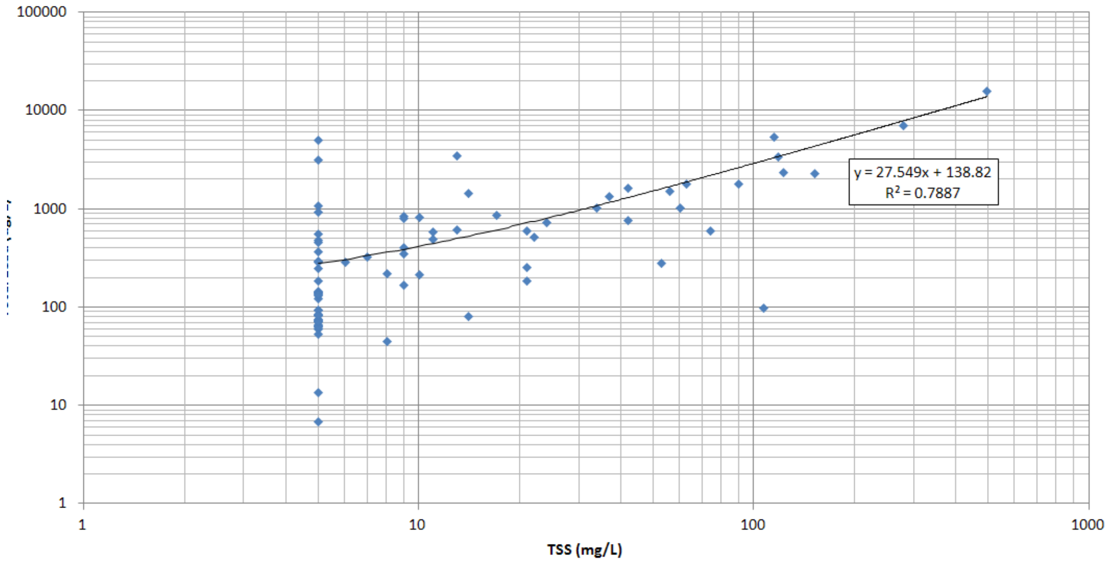


Figure 2-13. Correlation of Total Lead with Total Suspended Solids at Viburnum 29 Mine.

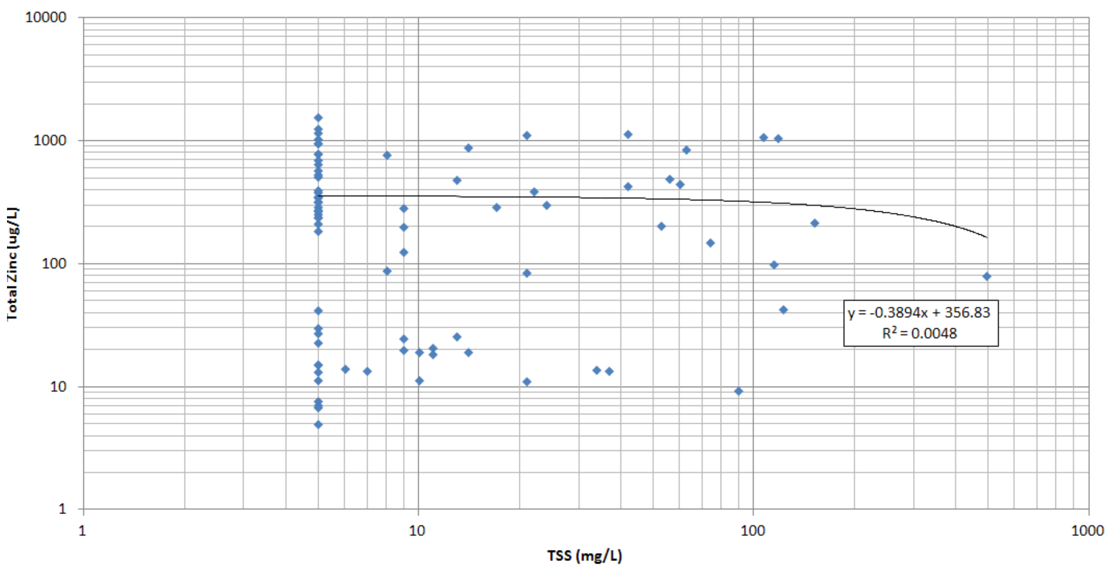


Figure 2-14. Correlation of Total Zinc with Total Suspended Solids at Viburnum 29 Mine.

2.2.5 Comparison of Underground and Surface Mine Water

Mine water data at the underground sump at Viburnum 29 were compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. The results are plotted in Figures 2-15 through 2-18 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is not possible because the underground and surface samples were not collected on the same dates in every case and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made:

- The results indicate that total cadmium and zinc are slightly higher in the underground mine water samples collected at the main mine water sump than in the surface mine water samples, but the differences are not significant.
- Copper appears to be generally present at higher concentrations in surface mine water samples than in the underground mine water samples. There is no apparent explanation for this.
- Lead appears to have similar concentrations in surface and underground mine water samples.

Ongoing sampling at Viburnum 29 will include underground and surface mine water and these data will continue to be evaluated as they are available.

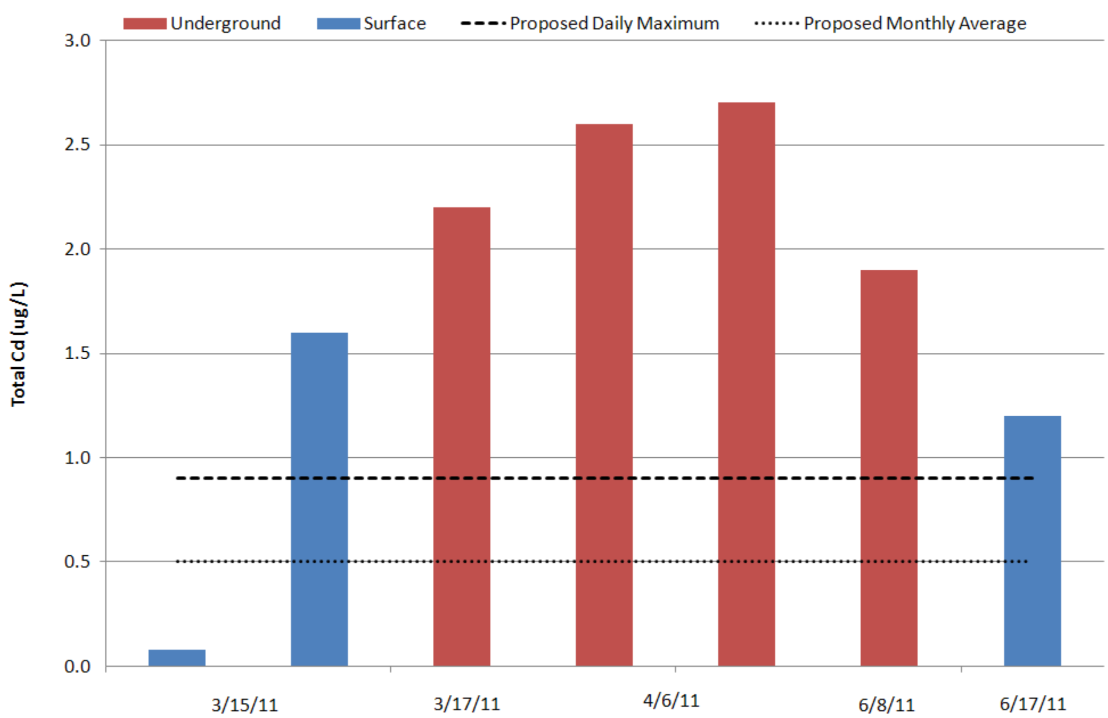


Figure 2-15. Total Cadmium in Underground (sample location Main Sump INF) vs. Surface (sample location MWB1In) Mine Water at Viburnum 29 Mine.

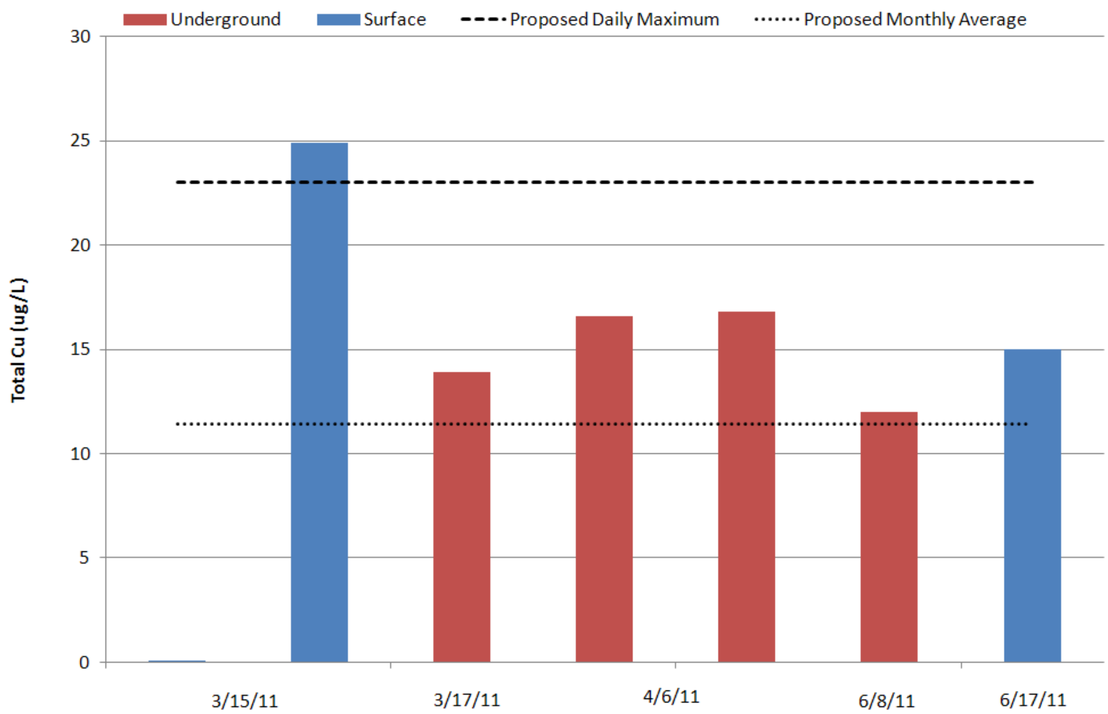


Figure 2-16. Total Copper in Underground (sample location Main Sump INF) vs. Surface (sample location MWB1In) Mine Water at Viburnum 29 Mine.

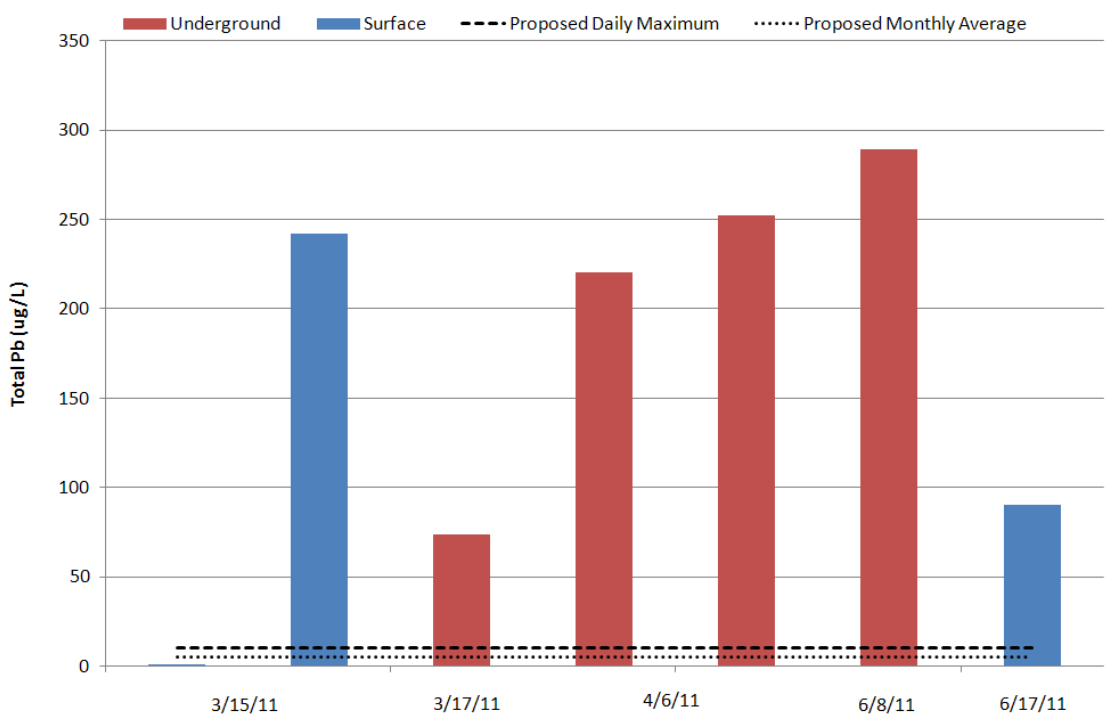


Figure 2-17. Total Lead in Underground (sample location Main Sump INF) vs. Surface (sample location MWB1In) Mine Water at Viburnum 29 Mine.

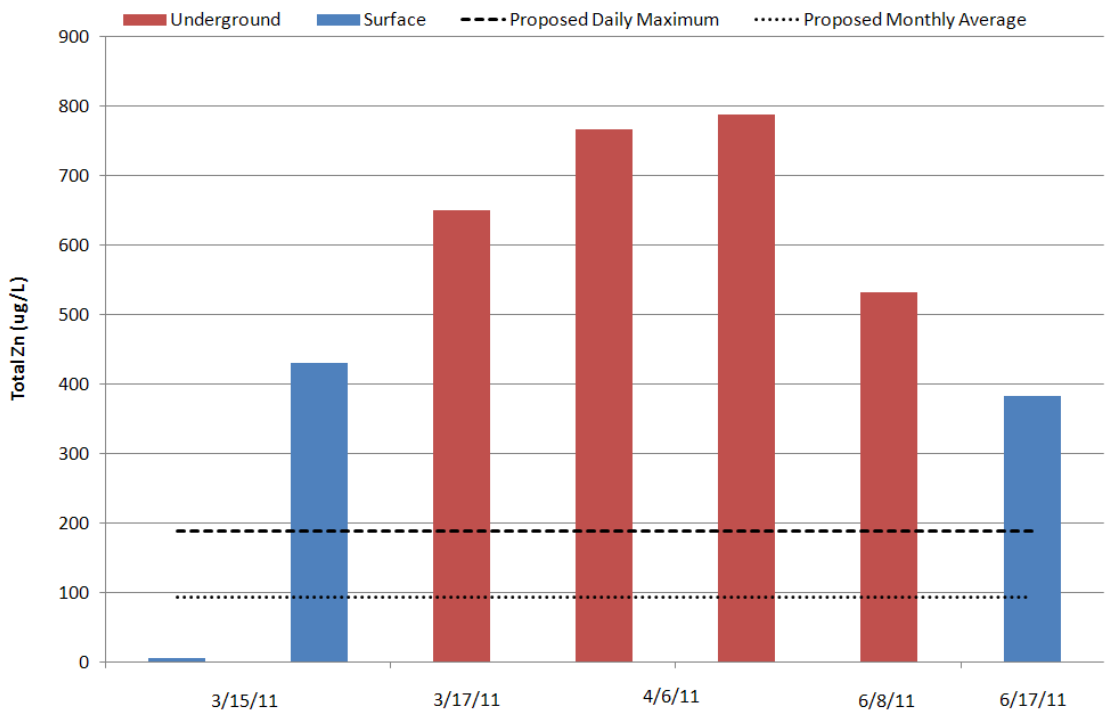


Figure 2-18. Total Zinc in Underground (sample location Main Sump INF) vs. Surface (sample location MWB1In) Mine Water at Viburnum 29 Mine.

2.2.6 Comparison of Mine Water at the Head and End of Pipe Runs

Mine water data at the head and end of four pipe runs within Viburnum 29 Mine were compared to evaluate whether the two are comparable in terms of metals content. The results are plotted in Figures 2-19 through 2-22 for total cadmium, copper, lead, and zinc, respectively. Pipe pairs are separated by a vertical line with bars depicted in the same color but different shading. Bold shades represent the samples at the head of the pipe, and muted colors represent samples at the end of the pipe.

Table 2-6. Samples at the Head and End of Pipe Runs within Viburnum 29 Mine.

Location	Represents	Pair
23 DEV Pump	Head of Pipe	1
23 DEV Discharge	End of Pipe	1
V10 Sump	Head of Pipe	2
Perch Pond Discharge	End of Pipe	2
217-32 Pump	Head of Pipe	3
217-32 Discharge	End of Pipe	3
12W Pump	Head of Pipe	4
12W Discharge	End of Pipe	4

The flowing observations regarding metals of interest can be made from these plots:

- Cadmium: Cadmium concentrations tend to increase within pipe runs 1, 2, and 4 and tend to decrease in pipe run 3. Pipe runs 1 and 2 tend to exceed the daily maximum and monthly average future final effluent limits. Whereas, pipe runs 3 and 4 tend to fall below the limits.
- Copper: Copper concentrations tend to increase within pipe runs 1, 2, and 4 and tend to decrease in pipe run 3. Pipe run 3 tends to exceed the daily maximum and monthly average future final effluent limits. Whereas, pipe runs 1, 2, and 4 tend to fall below the limits.
- Lead: Lead concentrations tend to increase within pipe runs 1 and 4 and tend to decrease in pipe runs 2 and 3. All pipe runs exceed the daily maximum and monthly average future final effluent limits.
- Zinc: Zinc concentrations tend to increase within pipe runs 1, 2, and 4 and tend to decrease in pipe run 3. Pipe runs 1 and 2 tend to exceed the daily maximum and monthly average future final effluent limits. Whereas, pipe runs 3 and 4 tend to fall below the limits.

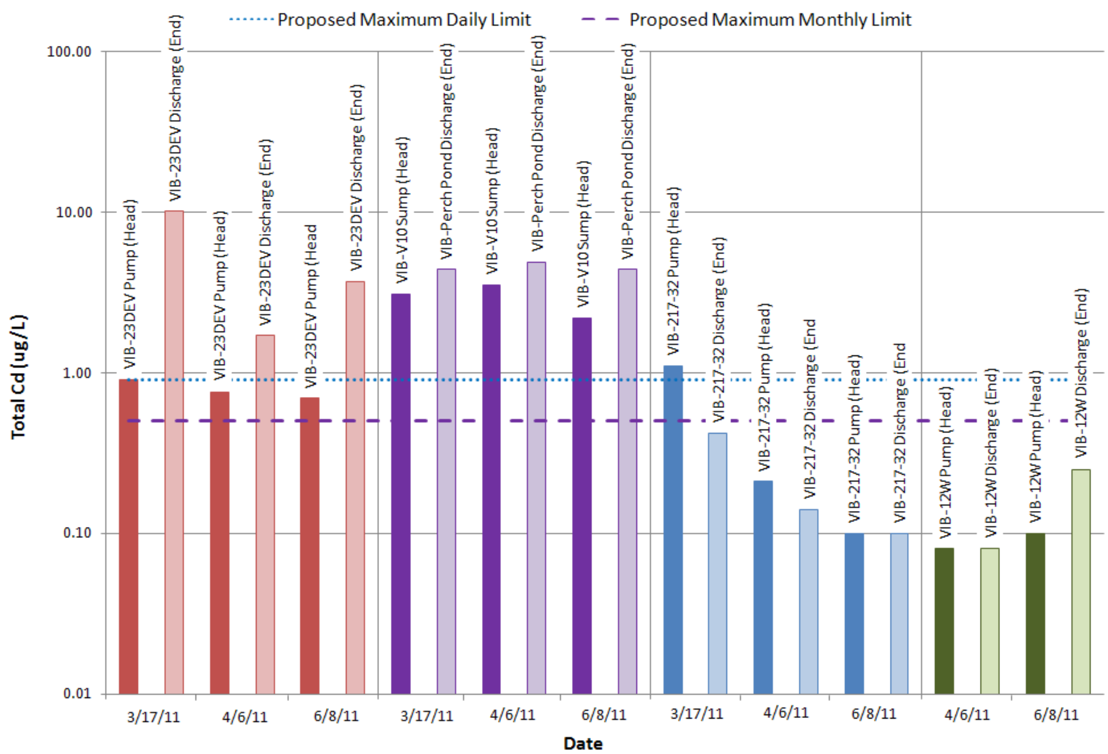


Figure 2-19. Total Cadmium in Head vs. End Mine Water at Viburnum 29 Mine.

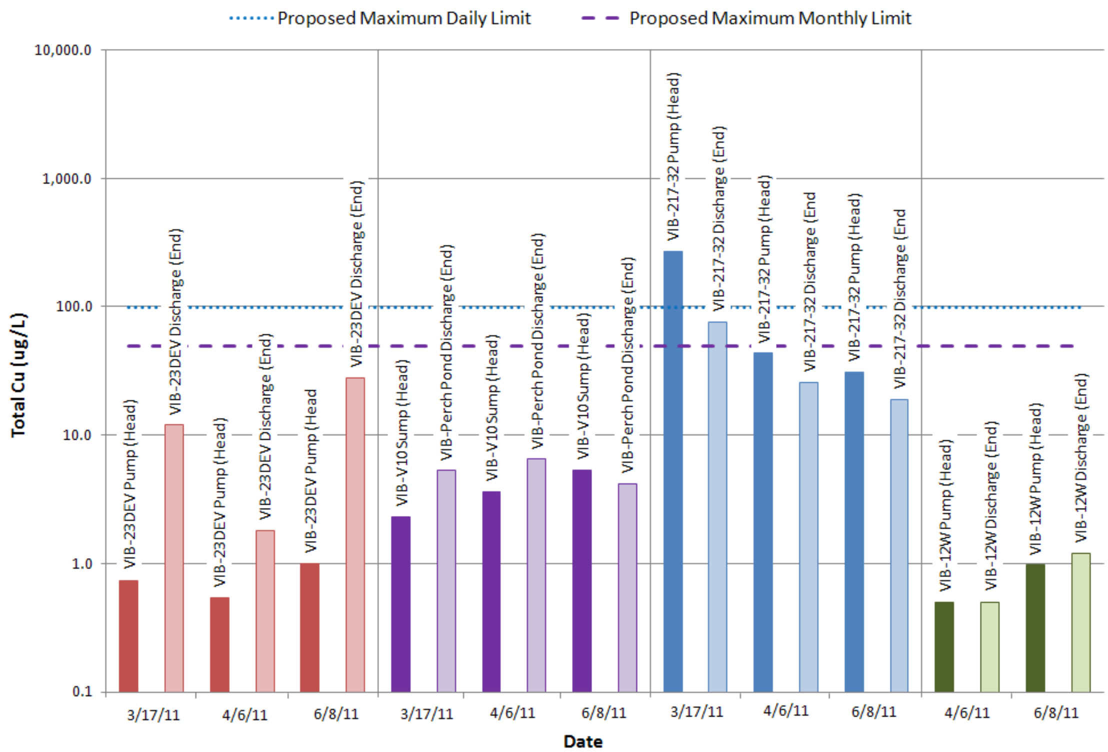


Figure 2-20. Total Copper in Head vs. End Mine Water at Viburnum 29 Mine.

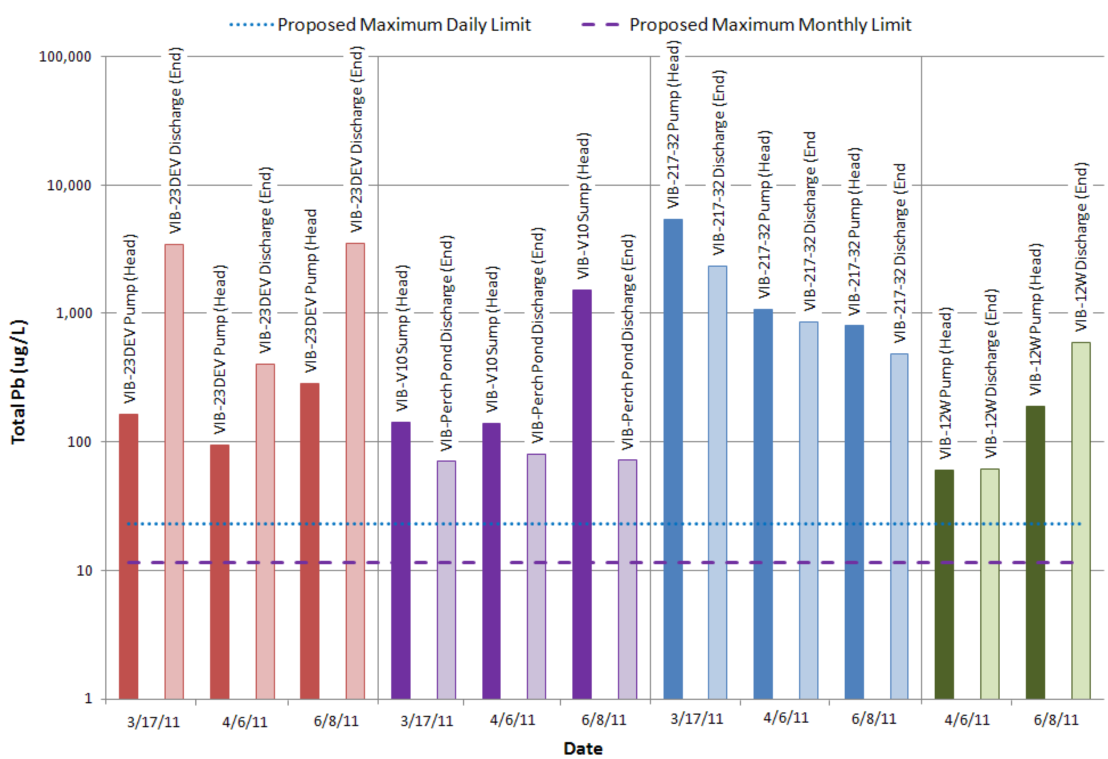


Figure 2-21. Total Lead in Head vs. End Mine Water at Viburnum 29 Mine.

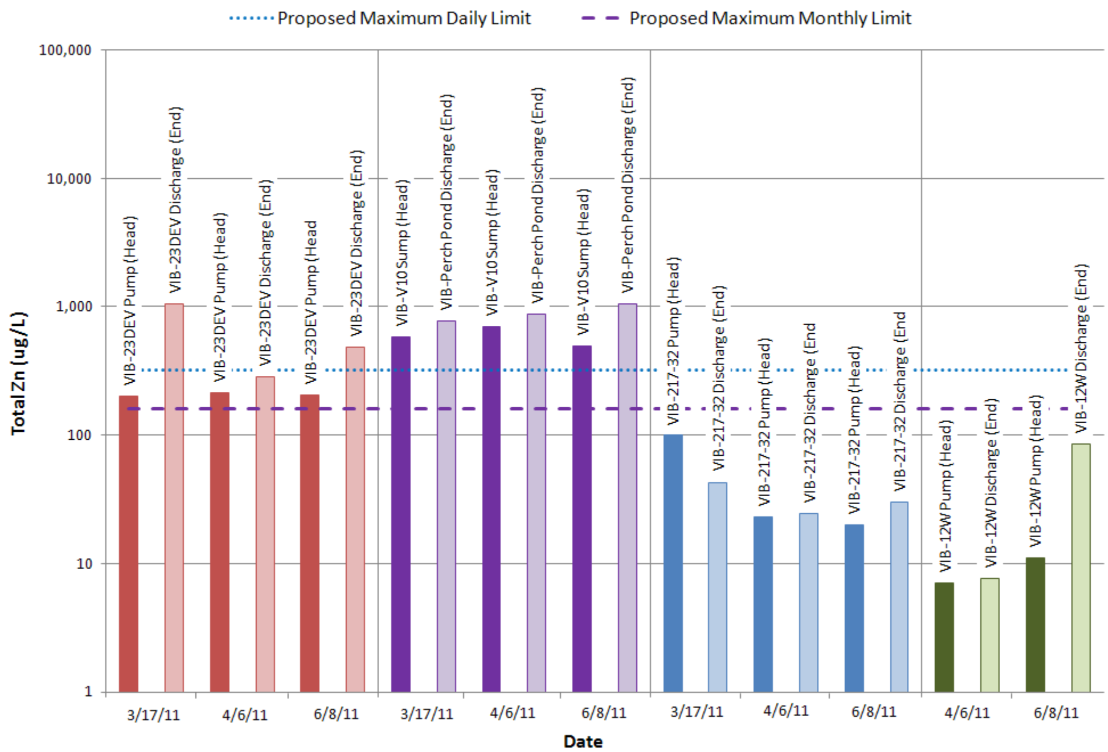


Figure 2-22. Total Zinc in Head vs. End Mine Water at Viburnum 29 Mine.

Some of the data presented above indicate that, even after water is conveyed through piping in the mine, the concentrations of metals in the water can be higher at the downstream end of the pipe run. It is unlikely that the metals are increased by the pipe itself, therefore it stands to reason that exposure to mine working are causing the increased metals after the water leaves the pipe run. This suggests that the more complete the isolation of mine water by piping, the more effective piping will be at preserving water quality. Ongoing sampling at Viburnum 29 will sampling at these locations and these data will continue to be evaluated as they are available.

2.3 SUMMARY OF MINE WATER SOURCES AND CONDITIONS

The findings of the preceding discussion of mine water at Viburnum 29 Mine can be summarized as follows:

- The average flow of water entering Viburnum 29 Mine and being pumped to the surface is estimated at 600 gpm.
- Of this total mine water flow, approximately one third of the flow comes from the South Branch of the mine and another third of the total flow comes from the road rock hole.
- The single largest source of mine water at Viburnum 29 Mine is the road rock hole, which contributes approximately 200 gpm.

- Incoming mine water has relatively low metals concentrations, but exposure to the mine workings significantly increases those concentrations, with the exception of copper.
- Increased suspended solids in mine water appear to increase total lead and total copper, but does not affect total cadmium and total zinc.
- The median concentration of cadmium in the south branch exceeds both the monthly average and daily maximum future final effluent limits. The median cadmium concentration in the north branch exceeds the future final monthly average limit, but not the daily maximum future final limit. The median concentration of cadmium in the Czar branch falls below both future final limits.
- The median concentration of copper in the Czar branch exceeds the monthly average effluent future final limit, but not the daily maximum future final limit. The median of the north branch falls just below the future final daily limit and well below the monthly future final limit; the median for the Czar branch falls below both limits.
- Concentrations of lead in most mine water samples, excluding incoming mine water, exceed the daily maximum and monthly average future final effluent limits for lead.
- Much higher total zinc concentrations were detected in the mine water samples from the north and south branches of Viburnum 29 Mine than the Czar branch. The median zinc concentration in the north branch falls just below both future final effluent limits and the median concentration in the south branch falls just above the monthly average and daily maximum future final limits. Concentrations in the Czar branch fall well below both limits.
- Metals concentrations within pipe runs either improved or degraded within the pipe. Ongoing sampling at Viburnum 29 will sampling at these locations and these data will continue to be evaluated as they are available.

Some possible water management approaches for Viburnum 29 mine for consideration as a result of these findings, include:

- Evaluate the effectiveness, technical feasibility, and cost-effectiveness of measures that minimize exposure of water entering the mine to mine workings.
- Evaluate options that are effective, technically feasible and cost-effective to minimize the introduction of suspended solids to mine water in an effort to reduce total lead concentrations.

These water management approaches were used to evaluate potential water management measures, as discussed in Section 3.

3. WATER MANAGEMENT MEASURES

This section of the plan presents several potential water management strategies and evaluates them in the context of Viburnum 29 Mine. In keeping with the Master Underground Water Management Plan, this section discusses the following types of possible measures:

- Isolation measures (Section 3.1)
- Treatment measures (Section 3.2)
- Groundwater interception (Section 3.3)
- Best management practices (Section 3.4)

A summary of the evaluation of these measures for Viburnum 29 Mine is presented in Section 3.5. It should be noted that this Section discusses potential underground water management measures and that these measures are not necessarily all planned for implementation at Viburnum 29 Mine. Section 4 describes which of these measures are planned for implementation and further evaluation of their effectiveness, technical feasibility, and cost-effectiveness at Viburnum 29 Mine. It should also be noted that Doe Run is currently evaluating the technical feasibility and probable costs of treating mine water at the surface and these evaluations will provide a point of comparison with potential underground water management measures to evaluate the cost-effectiveness of those measures.

3.1 ISOLATION MEASURES

Isolation measures are measures designed to isolate mine water from materials/processes that have the potential to increase metals in the mine water. The objective of isolation technologies is to eliminate or reduce the potential for mine water to contact or be exposed to environments that have the potential to increase the metals load.

3.1.1 Piping Water

In many locations in the mine, mine water flows via gravity in roadside ditches. In some places in Viburnum 29 Mine, where it is necessary to pump water due to grade changes, the water flows through pipes. In areas where there is open water in ditches and piping is not used, the water surface is exposed to loading of solids and metals from the roadways, mobilized by passing trucks and machinery. Because of this potential exposure, piping presents a potential control measure for improving water quality.

Areas of Viburnum 29 Mine that are currently piped are shown on the map in Appendix A. Piping used in the mine typically consists of high density polyethylene (HDPE) pipe, with 8-inch and 10-inch diameter (nom.) being the most common size used for long runs at Viburnum 29. The unit cost for these pipe materials ranges from \$7 to \$10 per linear foot (l.f.) for 8” pipe and \$11 to \$17 per l.f. for 10” pipe. These are materials costs based on current vendor pricing and do not include labor for installation.

Review of sampling data from other Doe Run mines shows that water quality is reduced within a short distance of water entering the mine, which suggests that, for piping to be an effective control measure, water must be captured very close to the source before significant exposure to mine workings. This is not possible in every circumstance. However, piping may be implemented on a localized basis at the Viburnum 29 Mine as a water quality management measure where the company determines that the measure will be effective in controlling water quality and will be cost-effective.

3.1.2 Lined Channels

Roadside channels in the mine allow contact between flowing water and the underlying rock. This contact may cause an increase in metals concentration, so lining of the channels was evaluated. Lining would involve placement and anchoring of an impermeable material on the bottom of the ditch to prevent the water-rock contact. This approach has not been tested but may be less effective than piping because it only addresses the issues of contact between flowing mine water and underlying rock, whereas piping should isolate mine water from the surrounding mine workings, as well as the underlying rock. In addition, sediment could accumulate in the lined channel over time and defeat the purpose of the lining. For these reasons, channel lining is not considered for evaluation as a potential water quality control measure for Viburnum 29 Mine.

3.1.3 Work Area Isolation

As described in the Master Underground Water Management Plan, work area isolation includes “isolating or compartmentalizing those areas to prevent the migration of materials into the water conveyance system.” The master plan suggests work areas may be separated from the remainder of the mine by physical measures such as berms, entrance tunnel modifications, or preplanning of new mine area configurations.

The feasibility of these potential measures was discussed with mine personnel. The challenge to implementing these measures is that they will interfere with mining operations. For example, berms placed between drilling or ore loading areas and water drainage channels will interfere with the passage of vehicles. It is impractical to build the berms up and tear them down every time a vehicle or piece of machinery needs to leave the work area. Entrance tunnel modifications and new mine area pre-planning involve designing tunnels so that a high point exists between work areas and the rest of the mine, to prevent the drainage of water impacted by mining activities from leaving the work area. This technique is impractical in most cases because the prevention of mine water drainage from work areas will result in flooding of those work areas. For the reasons discussed above, work area isolation is not considered for further evaluation as a possible water quality control measure for Viburnum 29 Mine.

3.1.4 Capture of Drill Fines

The Master Underground Water Management Plan also identified the capture of drill fines as a potential control measure. As stated in the Master Underground Water

Management Plan, drilling is conducted for both mine development and ore recovery operations and the drilling process produces fines which have the potential to become suspended in mine water. Three types of drilling are used at Viburnum 29 Mine:

- Jackhammer drilling is a percussion drilling method used for exploratory drilling in the mine. This is a “wet” drilling technique that generates fine material from the borehole that is carried away from the borehole by water.
- Core drilling is a second exploratory drilling technique that uses water to flush fines away from the core barrel and bit to extract a rock core form the borehole. Drill fines are generated during drilling and carried from the borehole by water.
- Production drilling is a percussion drilling method used during mining operations that can be either air mist or water cooled. Fines are generated in the borehole and carried out of the borehole by water or air.

In general, the quantity of fine materials generated during drilling is relatively small and the water generated during wet drilling is very small relative to other sources of flow in the mine. It is generally infeasible to capture drill fines from any of the above techniques because any method used to capture these fines would substantially interfere with drilling operations. For these reasons, capture of drill fines is not considered for further evaluation as a possible water quality control measure for Viburnum 29 Mine.

3.2 TREATMENT MEASURES

One type of underground water control measure considered for improving mine water quality is to actually treat the mine water below ground. Treatment processes that may have the potential to improve the quality of mine water include clarification (settling) and filtration.

3.2.1 Clarification

Clarification is a treatment process that involves the removal of suspended solids from water by gravity settling. Simple clarification typically involves the use of basins or sumps that reduce the velocity of flowing water, which allows a portion of suspended solids to settle. Enhanced clarification usually involves the addition of chemicals to facilitate coagulation and flocculation of fine particles that will not settle on their own. These processes are described below:

- Coagulation is the process of adding chemicals to neutralize particle charges that keep particles dispersed. Once the charges of fine particles are neutralized, they will bind together more readily, forming larger particles. This process is often used when very fine particles are suspended.
- Flocculation is the process of providing suitable conditions for fine particles to bind together and often involves very gentle mixing.

Simple clarification is practiced in the Viburnum 29 Mine, in the form of mine water sumps. These sumps are located throughout the mine and acts as settling basins.

Simple clarification in the form of mine water sumps will be part of the overall mine water management plan for Viburnum 29 Mine.

Enhanced clarification using chemicals for coagulation/flocculation, on the other hand, can be a complex process, requiring careful monitoring, with addition of chemicals to adjust the pH of the water being treated for optimization of treatment, followed by readjustment of pH. The process of enhanced clarification results in residuals that are much more difficult to handle and dewater than simple clarification. Providing suitable conditions for settling of the flocculated solids typically requires specialized clarifiers. The challenges of this more complex form of water treatment underground are discussed in Section 3.2.3.

3.2.2 Filtration

Filtration refers to the process of physically separating suspended solids from water by passing the water through material that has openings finer than the suspended materials. This can be accomplished using granular filter materials (e.g., sand filters), woven fabrics, or fabricated plastic or metals filters. The advantage of filtration over clarification is that it results in a more complete separation of water and solids, with the residual solids having lower water content than the residuals of clarification.

Filtration of mine water can potentially be accomplished underground in two ways. First, filters can be used between water sources and water conveyances, to remove suspended solids nearer the source. Second, filtration could be used as a centralized treatment process, immediately prior to pumping of mine water to the surface. The use of filtration between water sources and conveyance systems may have potential underground and may be part of the underground water management plan at Viburnum 29 Mine. Examples of this are the use of sand berms between flowing coreholes and water collection areas, and filter fabric wrapped around perforated HDPE drainage piping along roadways. Centralized filtration of mine water faces similar challenges as other centralized water treatment processes underground, which are discussed in the following section.

3.2.3 Overall Assessment of Underground Mine Water Treatment Feasibility

Mine water treatment processes, such as filtration between water sources may be feasible treatment practices for mine water underground. Still, further evaluation is needed to determine the impact of these practices on mine water quality and whether or not they are cost effective. Clarification by means of a centralized mine water sump is currently used at Viburnum 29 Mine and will continue to be a part of the overall water management plan. However, other forms of centralized (i.e., large-scale) underground mine water treatment present several challenges including:

- Available space – Centralized treatment will require a substantial amount of space in the mine. While space is often readily available at the surface, it must be created in the mine by excavating rock. Areas where mining has already occurred are not good candidates because of the possibility that Doe Run may want to return in the future and extract pillars. New areas are expensive to

create; the estimated cost of excavating rock underground is $0.60 per cubic foot (c.f.). In order to build only a sump, approximately a half million cubic feet of rock would need to be excavated, and that only includes the space needed to contain the water. In addition, because the same equipment and personnel would be used to excavate the area for treatment as would be used for mining there is a cost in lost ore production.

- Protection of treatment processes – It would be difficult to prevent treatment processes from being exposed to airborne dust in the mine, which could cause additional metals loading to the treatment system or otherwise upset the processes.
- Specialized operators – The types of treatment that would be required to reduce metals in mine water, aside from simple settling, would likely require trained operators. Such personnel are not currently deployed underground by Doe Run and their deployment underground would be more costly than above ground.
- Management of residuals – One of the biggest challenges for underground mine water treatment is the management of residuals. Although settled materials can be managed using conventional construction equipment, materials settled by flocculation have higher water content and would likely require specialized equipment. In addition, because they are flowable, they would require larger areas for disposal (i.e., they cannot be piled).

The use of mine water sumps for clarification (both distributed throughout the mine and at centralized locations prior to pumping to surface) will both be part of the underground water management plan for Viburnum 29 Mine. Other types of centralized underground mine water treatment do not appear to be feasible at Viburnum 29 Mine because of the challenges outlined above and will not be evaluated further.

3.3 GROUNDWATER INTERCEPTION

Groundwater interception is used here to include all measures that prevent water from entering the mine. Water can enter mine areas in a few ways:

- Coreholes – This refers to exploratory borings advanced from the surface to mine depth or from within the mine into the mine face, used to identify ore locations and direct mining activities. Coreholes sometimes intercept fractures and voids in the rock that convey water and then act as drains to allow water from the rock to enter the mine. To date, this has not been a significant source of water entering Viburnum 29 Mine.
- Access and vent shafts – These are large-diameter shafts constructed from the surface to mine depth to allow access by personnel and equipment, removal of ore, and ventilation of mine areas. Because they intercept overlying aquifers and penetrate aquitards between the overlying aquifers and the mine, they can become major water sources to the mine. Casing is usually installed in these shafts, which greatly reduces flows. Flows into these shafts can also come

from storm water at the surface, although this contribution is relatively small compared to other flows.

- Fractures – Rock fractures are naturally occurring and mining activities at Viburnum 29 occur in an aquifer to begin with, so it is common for those mining activities to intersect water-bearing fractures. When this occurs, the fractures become a means of water entry into the mine.

The primary methods available to intercept groundwater before it enters the mine are sealing of coreholes and fractures, casing of shafts, and aquifer dewatering to prevent groundwater from entering coreholes, shafts, and fractures.

3.3.1 Corehole and Fracture Sealing

When mining operations intersect coreholes and fractures, they can become a source of water to the mine. This can be true for a surface corehole if the corehole was incompletely sealed after drilling or if the seal has somehow failed over time. The Doe Run standard operating procedure for exploratory coreholes requires that coreholes penetrating the Davis shale must be fitted with an expandable packer within the bottom part of the formation and the hole must be filled with grout to at least 50 feet above the top of the Davis formation. The standard operating procedure remains in effect.

If a leaking corehole is encountered during mining operations, the corehole can sometimes be sealed using mechanical packers or grout. Mechanical packers have historically been used and have been shown to be effective, although in some cases stopping the flow from a corehole has caused the flow to enter the mine elsewhere. Viburnum 29 Mine personnel may plug coreholes that yield significant flow when they are encountered during mining, however, this has not been necessary in recent years because most coreholes encountered at the Viburnum 29 Mine do not have significant flows. In general, mostly at other mines, Doe Run has been evaluating the use of chemical grouts. Two types of chemical grout have been tested at the Fletcher Mine with limited results:

- Two-part grout: This is a two-component grout sold under the trade name H2OSTOP and it has been used for high-inflow coreholes. The grout reacts and sets within seconds of mixing, which is accomplished during injection by a static mixer inside a packer that is inserted in the corehole. The grout can expand in volume up to 20:1 and costs about $195 per cubic foot.

- Moisture-reactive grout: This is a single component grout sold under the trade name Hyperflex that sets in contact with water and is used for lower flow applications. This grout can also expand in volume up to 20:1 and costs about $397 per cubic foot.

These grouts can be effective for sealing fractures as well. Vendor information for both of these products is included in Appendix B. There is no reliable way to estimate how much material will be required to grout a corehole. In the last year, an estimated 200 cubic feet of product has been used. Corehole and fracture sealing will be a part of the underground water management plan for Viburnum 29 Mine, where it is feasible, technically possible, and cost-effective to do so, however at this time, there is not a significant need for this activity because, as stated above, most coreholes encountered at the Viburnum 29 Mine do have yield significant flows.

3.3.2 Shaft Sealing/Repair

Because access and ventilation shafts are necessary for the safe and productive operation of the mine, they cannot be eliminated. Although it is not possible to completely seal the shaft to prevent any water from entering the shaft (and therefore the mine), the standard practices employed by Doe Run are usually capable of eliminating most of the flow. These practices involve the installation of casings in the shafts to seal out water. At present, the shafts at Viburnum 29 Mine are not a major source of mine water flow, with the exception of the road rock hole. The road rock hole was plugged in August 2012. Aquifer Dewatering

The only other potential flow reduction measure to prevent water from entering the mine is interception of the groundwater in the aquifer before it reaches the mine. This would require installation of dewatering wells at critical points around the mine, at the depth of the contributing aquifers, and pumping of groundwater from the wells. Implementation of aquifer dewatering is a substantial and costly undertaking that would typically only be evaluated for very large sources of flow. Aquifer dewatering would require the following steps:

- Hydrogeological investigation to fully characterize water-bearing units around and above the mine.
- Installation of pumping wells to test the rates at which water could be pumped from the aquifer and the drawdowns in potentiometric surface that could be achieved.
- Evaluation of the ability of pumped groundwater to meet surface water future final discharge limits
- Upon completion of the above testing, the dewatering system would be designed and constructed.

One major advantage of this approach is that it involves pumping of groundwater to the surface before it comes into contact with the mine workings. This would presumably eliminate the need for treatment at the surface, prior to discharge. It is likely not feasible, however, to use aquifer dewatering for an entire mine, miles in length, due to the costs involved. Localized aquifer dewatering may potentially be used as a short-term measure to temporarily reduce flow in order to facilitate repairs to shaft casings. The road rock hole was the only shaft that was a major source of water and has already been sealed, therefore, aquifer dewatering is not considered for further evaluation as a possible water quality control measure for Viburnum 29 Mine.

3.4 BEST MANAGEMENT PRACTICES

There are several underground water management practices that can potentially be used to maintain or improve mine water quality. These are referred to as best management practices (BMPs) and several were identified in the Master Underground Water Management plan, including the following:

- Berms
- Channels
- Collection and Containment of Impacted Water
- Clean Mining Areas
- Material Handling and Storage
- Erosion Control
- Roadway Maintenance
- Maintenance Schedules

In addition, sump cleaning and inspection were identified as BMPs that should be considered. These BMPs are discussed below.

3.4.1 Berms

The use of berms was discussed previously in this plan (Section 3.1.3). Because even temporary berms will interfere with the movement of vehicles and equipment in the mine, where working space is already limited, it does not appear that their use is feasible, except in situations where flows can be directed to inactive mining areas, which is already done at Viburnum 29 Mine.

3.4.2 Channels

Shallow channels are already used throughout Viburnum 29 Mine to convey mine water flows. As discussed in Section 3.1.2, these channels are already problematic because they expose mine water to more impacts from mine workings. The potential for replacing open channels with enclosed pipes will be discussed in Section 4.

3.4.3 Collection and Containment of Impacted Water

Once water is impacted by exposure to mine workings, it should be isolated from unimpacted water. For example, if impacted water is created at the working mine face during ore extraction operations, it should not be mixed with unimpacted water seeping from coreholes, if this can be avoided.

3.4.4 Clean Mining Areas

In general, maintaining clean mining areas may help reduce the potential for mining activities to impact mine water. This “good housekeeping” practice will be employed to the extent possible in all mining areas and may include storage of ore, drill fines, waste rock, and mining equipment away from areas where water is collected.

3.4.5 Material Handling and Storage

This BMP refers to practices for handling and storage of materials that have the potential to impact mine water quality. This may include stockpiled ore or it may include solids removed from sumps during mucking. The practice for storing such material stockpiles will be that they are placed so as to minimize impacts to mine water.

3.4.6 Erosion Control

As described in the Master Underground Water Management Plan, erosion control in mines includes the protection of any surface that has the potential to erode and increase the loading of suspended solids. These areas include material storage piles and transportation corridors. At Viburnum 29 Mine, erosion control of storage piles will be addressed by material handling and storage practices and erosion control of transportation corridors will be addressed to the extent feasible by the roadway maintenance program.

3.4.7 Roadway Maintenance

The heavy traffic of trucks and mining equipment over mine roadways, which are normally constructed of crushed rock, can result in erosion of the road surface. This can have two related impacts on mine water quality. First, the erosion of road materials can move fine materials into roadside channels filled with water. Second, the erosion can result in a lowering of the road bed over time, which can eventually lead to flooding of the eroded part of the road. Regular inspection of roadways and prompt repair of eroded areas will be part of the underground water management plan for Viburnum 29 Mine.

3.4.8 Maintenance Schedules

Scheduling of maintenance activities related to underground water management at Viburnum 29 Mine will be driven by monitoring and inspection activities, as discussed in Section 4.

3.4.9 Sump Cleaning

At Viburnum 29 Mine, like all Doe Run mines, mine water flows via gravity and/or pumping to central sumps where it is then pumped to the surface. At Viburnum 29 Mine, a single central mine water sump is used.

All mine water sumps provide temporary storage for mine water and, as a result, can have potential for settling solids, proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids, by design. This means, however, that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, accumulated solids could eventually impair pumping. For these reasons, periodic maintenance of the sumps is required to remove solids. The process of sump cleaning is referred to as “sump mucking”.

Sump mucking involves temporarily draining the sump, then mechanically removing the accumulated solids from the sump. The solids are transported to an inactive area of the mine for storage, where they dewater by gravity drainage. Since they consist of fine rock and ore, the dewatered solids are sometimes added to the mined materials sent to the surface for processing.

Experience at Doe Run mines shows that sump cleaning results in excessive wear on the machinery that is used to remove the accumulated solids because the fine solids get into the mechanical and hydraulic components of the machinery and are abrasive. Significant costs can be incurred for equipment refurbishment after every sump mucking event. Because sump cleaning is a necessary component of mine operations, it will be continued in the future and is discussed further in Section 4.

3.4.10 Inspections

Regular inspection of mine water management measures will be an important part of the overall underground water management plan at Viburnum 29 Mine. These inspections will be used to monitor effectiveness of the plan and to identify the need for maintenance of roadways, piping, sumps, and other mine water management measures.

3.5 SUMMARY OF WATER MANAGEMENT MEASURE EVALUATION

Several of the potential control water management measures have been identified for the Viburnum 29 Mine as they may have the potential to reduce mine water flows and effect improving water quality. The measures are summarized in Table 3-1 along with notation on which will be part of the Viburnum 29 underground water management plan. In all cases, the use of the measures discussed here will be evaluated and implemented if Doe Run determines that the measures are effective, technically feasible, and cost effective, or will be further evaluated for potential implementation.

Table 3-1. Summary of Water Management Measure Evaluation for the Viburnum 29 Mine.

Type of Measure	**Measure**	**Assessment Summary**	**Included in Viburnum 29 UGWMP?**
Isolation	Piping	Potentially effective on a localized basis; to be evaluated further	Yes
	Channel lining	Not an effective control measure	No
	Work area isolation	Not feasible	No
	Capture of drill fines	Not feasible	No
Treatment	Clarification	Simple settling feasible; enhanced clarification infeasible	Yes
	Filtration	Potentially feasible on a localized basis; will undergo further evaluation	No
Groundwater Interception	Corehole/fracture sealing	Not currently needed; will be considered on an as-needed basis in the future	No
	Shaft repair/sealing	Not needed	No
	Aquifer dewatering	Not part of plan, pending outcome of investigations at Sweetwater Mine	No
Best management practices (all to undergo regular review and evaluation)	Berms	Useful in some case	Yes
	Channels	Necessary, piping preferred in some areas	Yes
	Collection/ containment	Potentially useful	Yes
	Clean mining areas	Potentially useful	Yes
	Material handling/storage	Potentially useful	Yes
	Erosion control	Addressed by material handling & roadway maintenance	No
	Roadway maintenance	Potentially useful	Yes
	Maintenance schedules	Necessary, driven by monitoring and inspections	Yes
	Sump cleaning	Necessary	Yes
	Inspections	Necessary	Yes

This page is blank to facilitate double sided printing.

4. PLAN ELEMENTS AND IMPLEMENTATION

The underground water management plan for Viburnum 29 Mine is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of potential measures focusing on cost-effectiveness and impact on water quality;
- Development of planned actions;
- Implementation of planned actions;
- Monitoring of implemented actions (data collection and inspection);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Viburnum 29 Mine plan discussed in this section are:

- Water management actions
- Best management practices
- Monitoring
- Inspection
- Recordkeeping
- Training
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections. It should be noted that mine water treatment evaluations are ongoing at Doe Run. The outcome of these evaluations will determine the most effective mine water treatment method, as well as an accurate estimate of the unit cost for mine water treatment. This will allow evaluation of potential underground water control measures in the context of relative cost-effectiveness, compared to treatment at the surface. Based on these comparisons, some of the measures discussed in this section may be determined not to be cost effective and may be removed from the plan in the future.

4.1 WATER MANAGEMENT ACTIONS

Based on the review of mine data discussed in Section 2 and the evaluation of potential control measures discussed in Section 3, no major water management actions are included in this plan for the Viburnum 29 Mine. However, two contingency plans will be set up for the Viburnum 29 Mine to address future potential opportunities for water management actions: corehole sealing contingency and piping contingency. These are described below.

4.1.1 Road Rock Hole Flow Reduction

As described in Section 2.1.2, the road rock hole at Viburnum 29 Mine was responsible for about a third of the mine water currently entering the mine, approximately 200 gpm which presented a significant opportunity for reducing mine water flows at the mine. The road rock hole was ten inches in diameter, and was plugged with concrete at the end of August 2012. The effectiveness of the plug will continue to be monitored through the end of 2012.

4.1.2 Corehole Sealing Contingency Program

Although coreholes are not currently a significant source of influent mine water at Viburnum 29 Mine, there is the possibility that coreholes may be encountered in the future that yield higher flows. For this reason, a corehole sealing contingency program will be implemented. This contingency program will include a standard operating procedure and decision framework for determining which coreholes will be sealed. This plan formalizes the framework for determining which coreholes will be sealed. New coreholes that are encountered during mining operations that produce significant flows to the mine may be sealed, if sealing is technically possible and cost-effective. If possible, the following procedure will be followed:

- Flowrate from the corehole will be estimated by measuring the time required to fill a 55-gallon drum or other similarly-sized container of known volume. If it is not possible to measure the flowrate from the corehole in this manner due to the location of the corehole and difficulty in positioning the container under the stream of flow, a 5-gallon bucket or similar smaller container shall be used. If this is also impractical due to the very small quantity of flow or for safety reasons, the underground water management team will discuss alternate flow estimation methods. Because flows from newly encountered coreholes sometimes vary, the flow will be measured once a month for three months.
- The diameter of the corehole will be measured to the nearest inch. If it is impossible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.
- After measuring the flow and the corehole diameter, the underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past. If the underground water management team is not certain whether sealing is feasible, they will consult with manufacturer’s representatives for mechanical plugs and grouts to help determine the feasibility of sealing the corehole.
- If it is determined that the corehole can be sealed, the underground water management team will determine a schedule for sealing that takes into account the priority of the action relative to other water management measures.

The above process is documented in the form of a standard operating procedure, included in Appendix C. Corehole sealing will be documented in writing. The methods and procedures used for sealing will be documented, along with problems encountered and apparent success of the sealing, for future reference.

4.1.3 Piping Contingency Program

No piping projects are currently planned for the Viburnum 29 Mine to address water quality. However, future circumstances may warrant consideration of such piping, so a contingency program for piping will be maintained as part of this plan. Where likely to protect water quality and where Doe Run determines it will be feasible and cost-effective, major mine water flows may be piped.

Data collected at Doe Run mines indicate that the quality of mine water entering mines can be degraded within a short distance of the point of entry. Therefore, before piping to maintain water quality, the underground water management team will continue to determine whether the piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation. This will likely be accomplished by containing the water at the point of entry with a sump or other system and piping directly from the sump to a main mine water sump.

If the source of the incoming water is a corehole, the procedures outlined in Section 4.1.2 will be followed before piping is evaluated. If the source of the water is a corehole that cannot be sealed, the underground water management team will use the following protocol to determine whether piping will be installed:

- The physical setting and surroundings of the source will be assessed by the underground water management team to identify options for containing the incoming flow as close to its source as possible. This process will consider quantity of flow, space availability, accessibility of the source, other mine operations, cost, and safety.
- Once the most feasible and cost-effective option for containing the flow is determined, the underground water management team will determine the flow path the water will follow to reach the containment area. Water samples will then be collected at the end of that flow path, at the point where water would enter the containment area, as well as the point of entry to the mine (i.e., the corehole, fracture, or shaft). This water sampling will follow the standard procedures for sampling that are currently in place for water sample collection.
- The sampling results will be compared to the results for the incoming water as a measure of the water quality degradation that will occur along the flow path to the location of the containment. The results will also be compared to water quality data from the mine water sump to which the water would be piped. The underground water management team will use these comparisons to determine whether the piping is likely to provide a significant water quality benefit and whether the piping is cost-effective.

All data collected during piping evaluations will be recorded. Upon review of new data in the future, if a piping project is determined to be ineffective, the piping project may be terminated or, if already installed, the piping may be removed for use elsewhere.

4.1.4 Ongoing Water Management Measure Evaluations

In addition to the corehole sealing and piping contingency programs described above, the following additional actions will be considered on an as-needed basis:

- Additional piping – As mine expansion occurs, significant inflows of relatively clean groundwater may be encountered and, in some cases, it may be feasible and cost-effective to contain the water locally and pipe it directly to mine water sumps. This measure will be evaluated by the water management team on a case-by-case basis.
- New corehole sealing techniques/materials – The water management team will continue to evaluate new techniques or materials for corehole sealing, as they become available.
- New mine water pump shafts – As mining operations progress, it may become feasible to construct new pump shafts to the surface, as an alternative to moving water from newly mined areas to existing mine water sumps. This will be evaluated by the water management team on an as-needed basis.
- Mine expansion – During mine expansion activities, mine personnel will consider water management strategies from a water quality, as well as logistical perspective and identify environmentally-appropriate water management strategies into the expansion design.

As with the planned activities described in the preceding section, control measure evaluations will be documented in future updates to this plan.

In addition to the contingency actions outlined above, best management practices, as described in Section 4.2, will be used to manage water quality.

4.2 BEST MANAGEMENT PRACTICES

Several BMPs will be implemented at Viburnum 29 Mine as part of this plan, as described in the following sections. Some of these BMPs, such as berms, channels, collection, and clean mining areas will likely be used relatively infrequently because of their limited applicability. Others, such as roadway maintenance and sump cleaning will be performed more frequently, but still on an as-needed basis. BMPs and the conditions where they may be useful will be discussed during personnel training.

4.2.1 Berms

Berms are low barriers used to direct flowing water in a desired direction, away from its natural course. Although the use of berms to contain water within work areas is infeasible due to interference with mining activities, as described in Section 3.1.3, berms may be useful in areas of the mine where active mining and hauling is not occurring. Berms may be considered a potential water management practice in areas where they will not interfere with mining.

4.2.2 Channels

Channels are shallow watercourses, usually along roadways, in the mine. Although allowing water to flow uncovered in channels has been identified as a source of water quality degradation, there may be situations where construction of channels will be useful. For example, as with berms described above, channels may be useful in diverting flow away from main mine water sumps towards unused or inactive areas of the mine. In such situations, a simple open channel might be used or a combination of channel and pipe may be used, where the diverted flow has to cross a roadway.

4.2.3 Collection/Containment

Collection or containment may be used, where feasible and cost-effective, in situations where water impacted by mining activities is in proximity to sources of relatively unimpacted water. Possible collection/containment techniques may include:

- Construction of a local sump to collect the impacted mine water or the unimpacted water source for pumping.
- Use of diversion channels or berms to direct the flow of impacted mine water away from the source of unimpacted water.

The appropriate method of collection or containment will be determined on a case-by-case basis. In situations where the unimpacted water source is a newly discovered corehole, the procedure for evaluating corehole sealing will be followed.

4.2.4 Clean Mining Areas/Material Handling and Storage

The ‘Clean Mining Areas’ and ‘Material Handling and Storage’ BMPs discussed in Sections 3.4.4 and 3.4.5 are combined here because they are closely related. This combined BMP refers to maintaining work areas in the vicinity of open mine water in such a way as to minimize the potential for water quality degradation. This is especially relevant to areas around sumps and around channels that have not been piped. Where possible, stockpiled materials such as ore and waste rock should be located to minimize impacts to water. Equipment should also be stored away from water where possible.

4.2.5 Roadway Maintenance

Roadways will be inspected on a regular basis by mine supervision personnel and any significant repairs will be documented. These inspections will be specifically directed at identifying roadway conditions that might contribute to water quality degradation including, but not necessarily limited to, the following:

- eroded sections of the roadway that are likely to contribute to the degradation of mine water quality (repaired by filling to an acceptable grade)
- broken or plugged drain pipes (repaired by replacing broken pipe or clearing plug)

- water entering from the back and falling onto the road causing erosion (repaired by suspended curtains of suitable material over the roadway to divert falling water to ditches)

It should be noted that there may be cases where a low point in a roadway exists because it is the low point of the mine tunnel and not necessarily due to erosion. In such cases, filling may create insufficient clearance between passing trucks and the back, so repair is not feasible. When appropriate, significant problems and repairs will be logged in the Doe Run Enterprise Task Management System (ETMS).

4.2.6 Maintenance Schedules

Maintenance related to underground water management at Viburnum 29 Mine will be performed on an as-needed basis. Regularly scheduled inspections may identify additional maintenance needs.

4.2.7 Sump Cleaning

The main mine water sump will be inspected once per calendar quarter as part of the routine water management inspection program at Viburnum 29 Mine. Part of this inspection will be reading of depth soundings to monitor the level of accumulated solids in the sump. If it is logistically feasible, the main mine water sump at Viburnum 29 Mine will be equipped with a sonar depth finder capable of measuring the depth to the sediment/water interface. If this equipment can be installed, initially, a decrease in water depth of 50% at a point in close proximity to the pumps will be used to trigger sump cleanout. This level of fill is based on the experience of mine personnel. As described below, the main mine water sump will be sampled on a regular basis and these data will be evaluated along with the level of accumulated sediment to determine whether a different level should be used to trigger sump cleaning. A standard operating procedure for monitoring sediment levels in main mine water sumps is included in Appendix C.

4.3 MONITORING

Ongoing underground water quality monitoring will be continued at the Viburnum 29 Mine to improve the understanding of mine water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 4-1 will be sampled, unless it is determined by Doe Run that an adequate amount of data has been collected.

Table 4-1. Underground Water Sampling Locations for the Viburnum 29 Mine.

Location	**Sample ID Previously Used**	**Rationale**
Main mine water sump influent	VIB-MNSPINF	Water quality entering sump
Main mine water sump near pumps	VIB-MNSPNEARPUMPS	Water quality leaving sump
CDH64	VIB-CZAR 6(CDH6)	Mine water quality entering Czar branch
Mine water ditch at south end of Czar branch	VIB-CZAR 1	Mine water from Czar branch to main sump
Mine water ditch at south end of north branch	VIB-NMINEDITCH	Mine water from north branch to main sump
Road rock hole	VIB-RDRKH*	Mine water quality entering from shaft
87V1/V15	VIB-87V1/V15 Discharge	Mine water quality in south branch
*Grouting of the road rock hole was completed in August 2012. Sample will no longer be taken from this location.		

Continued monitoring was initiated in November 2011, and has typically been conducted on a monthly basis. The results of the continued monitoring efforts are presented in Figures 4-1 through 4-5. Evaluation of the most recent data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

In addition to the monitoring regime described above, supplemental monitoring may be performed to evaluate various water management measures, in order to evaluate effectiveness of the measures and to inform the adaptive management process for underground water management at Viburnum 29 Mine.

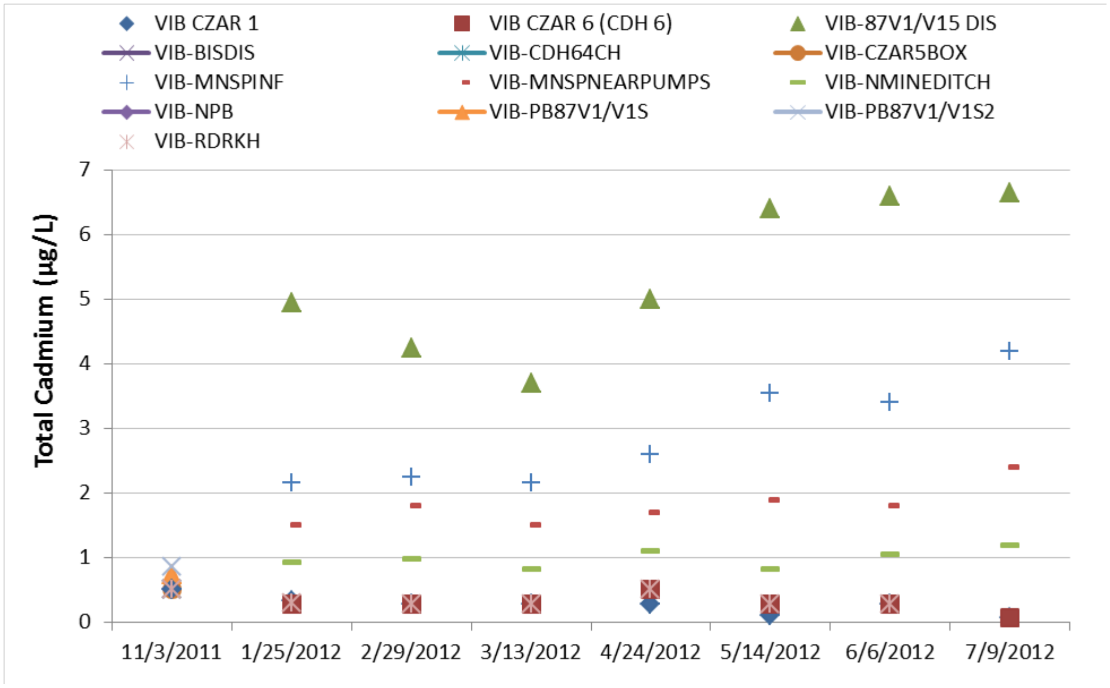


Figure 4-1. Continued Monitoring of Total Cadmium in Underground Sampling Locations at Viburnum 29 Mine.

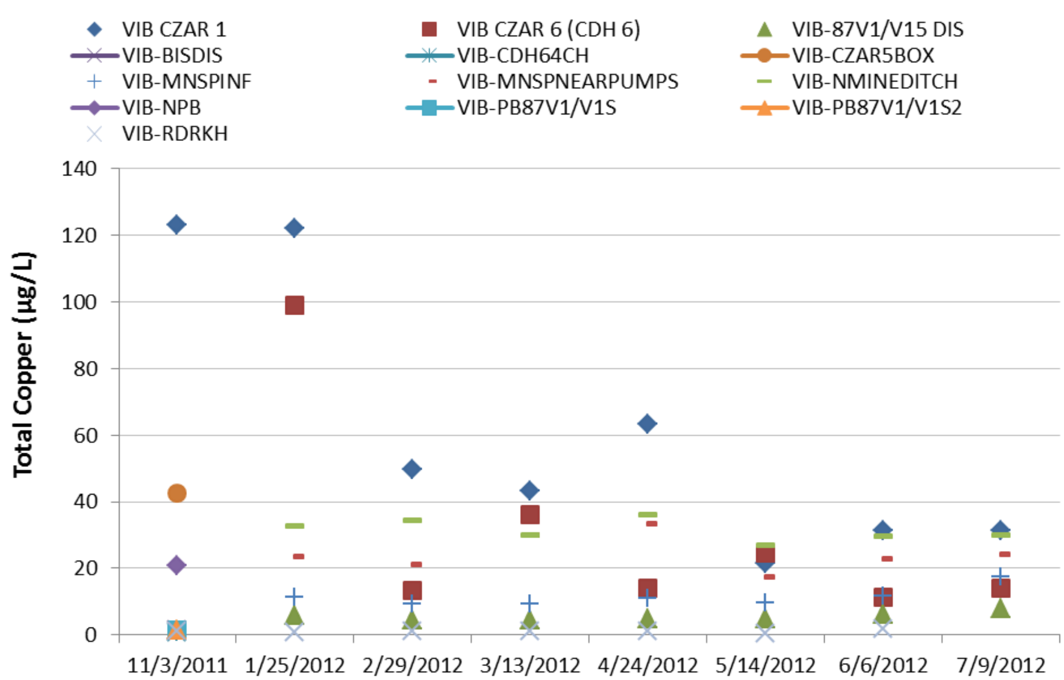


Figure 4-2. Continued Monitoring of Total Copper in Underground Sampling Locations at Viburnum 29 Mine.

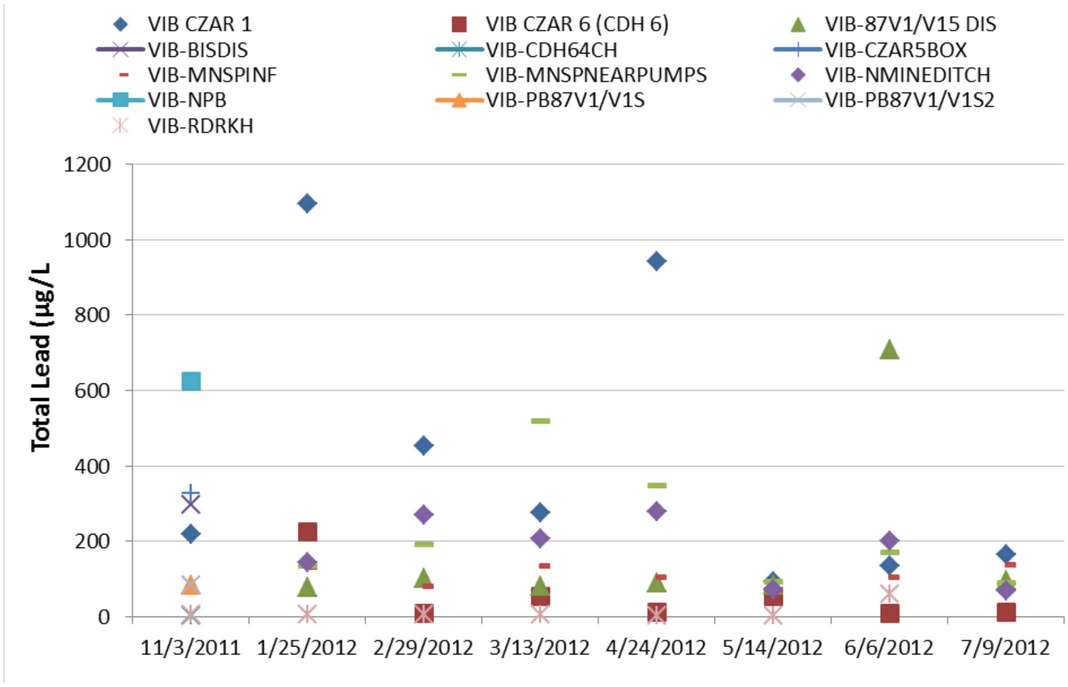


Figure 4-3. Continued Monitoring of Total Lead in Underground Sampling Locations at Viburnum 29 Mine.

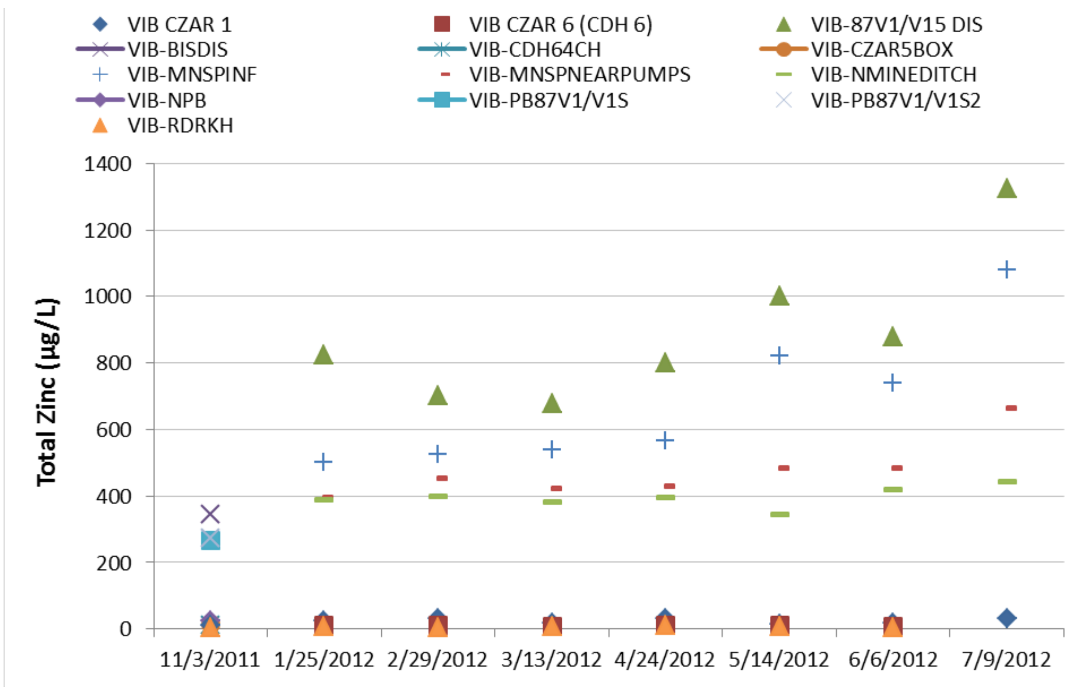


Figure 4-4. Continued Monitoring of Total Zinc in Underground Sampling Locations at Viburnum 29 Mine.

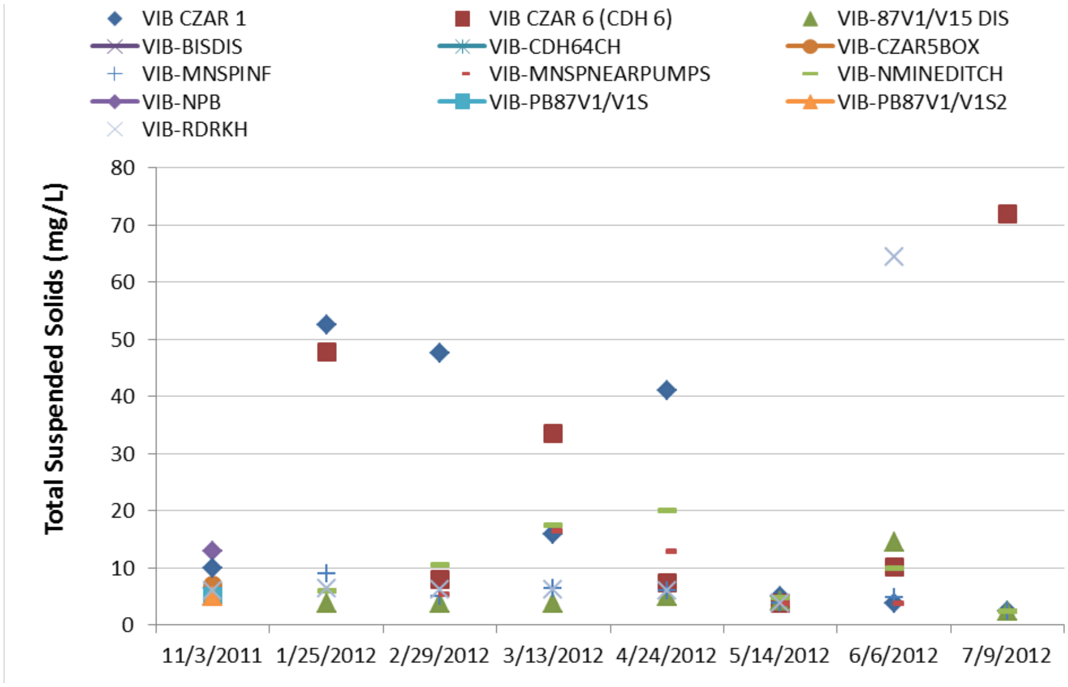


Figure 4-5. Continued Monitoring of Total Suspended Solids in Underground Sampling Locations at Viburnum 29 Mine.

4.4 INSPECTIONS

Underground water management inspections will be conducted at Viburnum 29 Mine once per calendar quarter basis to monitor effectiveness of water management measures and to identify the need for maintenance. Inspections will include visual inspection of the following:

- Main mine water sump to visually assess turbidity and general condition;
- Water piping, to identify leaks;
- Roadways, to identify the need for maintenance;
- Material and equipment storage areas to identify the need for improved separation from sources, conveyances, and sumps;
- Coreholes and/or fractures scheduled for sealing between the previous and current inspections, if any, to verify that sealing has occurred and was effective;
- Sources of water identified since the previous inspection; and
- Any other water management actions undertaken since the last inspection.

Inspections will be conducted by trained personnel (see Section 4.5). All inspections will be documented using the form in Appendix D, which will include the name and signature of the person performing the inspection.

4.5 TRAINING

Training was identified in the Master Underground Water Management Plan and will be an important part of the plan for Viburnum 29 Mine. Initial training will be provided by March 31, 2012 to all personnel involved in the management of water at Viburnum 29 Mine including, but not necessarily limited to:

- Mine supervision
- Mine engineers
- Technical service personnel
- Environmental technicians

In addition to the initial training for these personnel, annual refresher training will be conducted.

The purpose of the training will be to educate personnel in the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for underground water management (including the environmental need);
- Best management practices to be used throughout the mine;
- Specific water management actions being implemented or planned;
- Water management protocols and standard operating procedures;
- Inspections;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

4.6 TRACKING/RECORD-KEEPING

Water management measures will be inspected at Viburnum 29 Mine quarterly and the inspections will be documented on the form included in Appendix D. These forms will be kept on file on-site by the Viburnum 29 Underground Water Manager or designee. In addition, all significant water management measures and best management practices implemented at Viburnum 29 Mine will be documented in writing and a copy kept on file at the same location. Actions taken, best management practices, inspections, and maintenance of underground water management measures will be recorded in the Doe Run ETMS.

4.7 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between September 1 and October 31, 2012. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Viburnum 29 Mine facility.

4.8 IMPLEMENTATION SCHEDULE

The current schedule for the water management plan implementation is presented in Table 4-2. This schedule is based on the best information available as of the date of this plan.

Table 4-2. Current Implementation Schedule for Underground Water Management Plan Activities at Viburnum 29 Mine.

Action	Jan. 2012	Feb. 2012	Mar. 2012	April 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Mar. 2013	Oct. 2013	Dec. 2013
Training															
Inspections	Once per Calendar Quarter														
Sampling						As needed									
Road Rock Hole Sealing Investigation															
Plan Review & Update															

This page is blank to facilitate double sided printing.

5. REFERENCES

LimnoTech. Underground Water Sampling and Analysis Plan Report. August 4, 2011. (LimnoTech, 2011)

Resource Environmental Management Consultants, Inc. *Master Underground Water Management Plan: The Doe Run Company SEMO Operations*. 2010. (RMC, 2010)

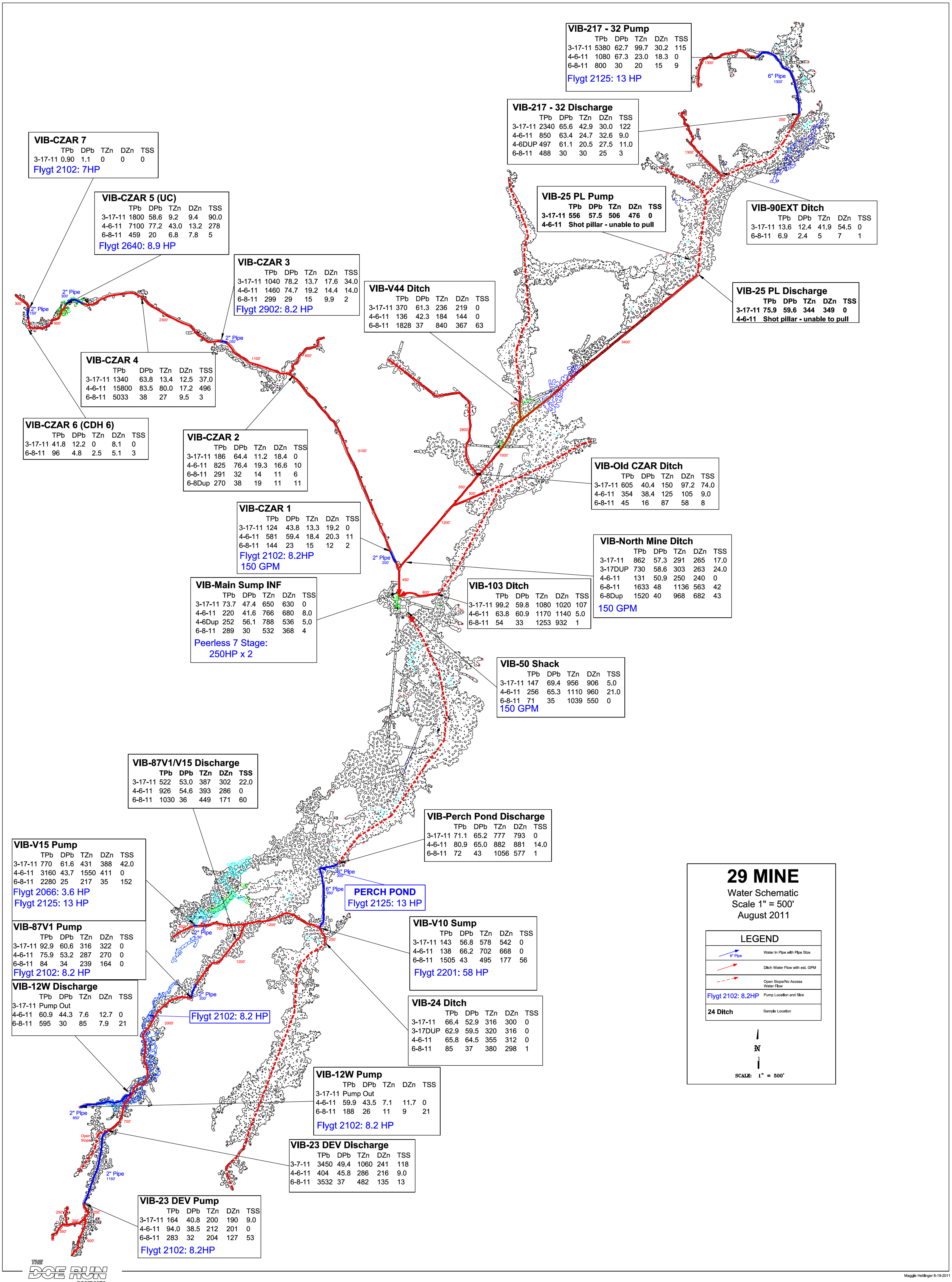
U.S. Geological Survey. “History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict” (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008)

This page is blank to facilitate double sided printing.

APPENDIX A:

VIBURNUM 29 MINE WATER FLOW MAP WITH LEAD AND ZINC SAMPLING RESULTS

This page is blank to facilitate double sided printing.



29 MINE

Water Schematic
Scale 1" = 500'
August 2011

LEGEND

6" Pipe	Water in Pipe with Pipe Size
	Ditch Water Flow with est. GPM
	Open Stope/No Access Water Flow
Flygt 2102: 8.2HP	Pump Location and Size
24 Ditch	Sample Location

N

SCALE: 1" = 500'

VIB-217 - 32 Pump

	TPb	DPb	TZn	DZn	TSS
3-17-11	5380	62.7	99.7	30.2	115
4-6-11	1080	67.3	23.0	18.3	0
6-8-11	800	30	20	15	9

Flygt 2125: 13 HP

VIB-217 - 32 Discharge

	TPb	DPb	TZn	DZn	TSS
3-17-11	2340	65.6	42.9	30.0	122
4-6-11	850	63.4	24.7	32.6	9.0
4-6DUP	497	61.1	20.5	27.5	11.0
6-8-11	488	30	30	25	3

VIB-CZAR 7

	TPb	DPb	TZn	DZn	TSS
3-17-11	0.90	1.1	0	0	0

Flygt 2102: 7HP

VIB-CZAR 5 (UC)

	TPb	DPb	TZn	DZn	TSS
3-17-11	1800	58.6	9.2	9.4	90.0
4-6-11	7100	77.2	43.0	13.2	278
6-8-11	459	20	6.8	7.8	5

Flygt 2640: 8.9 HP

VIB-25 PL Pump

	TPb	DPb	TZn	DZn	TSS
3-17-11	556	57.5	506	476	0
4-6-11	Shot pillar - unable to pull				

VIB-90EXT Ditch

	TPb	DPb	TZn	DZn	TSS
3-17-11	13.6	12.4	41.9	54.5	0
6-8-11	6.9	2.4	5	7	1

VIB-CZAR 3

	TPb	DPb	TZn	DZn	TSS
3-17-11	1040	78.2	13.7	17.6	34.0
4-6-11	1460	74.7	19.2	14.4	14.0
6-8-11	299	29	15	9.9	2

Flygt 2902: 8.2 HP

VIB-V44 Ditch

	TPb	DPb	TZn	DZn	TSS
3-17-11	370	61.3	236	219	0
4-6-11	136	42.3	184	144	0
6-8-11	1828	37	840	367	63

VIB-25 PL Discharge

	TPb	DPb	TZn	DZn	TSS
3-17-11	75.9	59.6	344	349	0
4-6-11	Shot pillar - unable to pull				

VIB-CZAR 4

	TPb	DPb	TZn	DZn	TSS
3-17-11	1340	63.8	13.4	12.5	37.0
4-6-11	15800	83.5	80.0	17.2	496
6-8-11	5033	38	27	9.5	3

VIB-CZAR 6 (CDH 6)

	TPb	DPb	TZn	DZn	TSS
3-17-11	41.8	12.2	0	8.1	0
6-8-11	96	4.8	2.5	5.1	3

VIB-CZAR 2

	TPb	DPb	TZn	DZn	TSS
3-17-11	186	64.4	11.2	18.4	0
4-6-11	825	76.4	19.3	16.6	10
6-8-11	291	32	14	11	6
6-8Dup	270	38	19	11	11

VIB-Old CZAR Ditch

	TPb	DPb	TZn	DZn	TSS
3-17-11	605	40.4	150	97.2	74.0
4-6-11	354	38.4	125	105	9.0
6-8-11	45	16	87	58	8

VIB-CZAR 1

	TPb	DPb	TZn	DZn	TSS
3-17-11	124	43.8	13.3	19.2	0
4-6-11	581	59.4	18.4	20.3	11
6-8-11	144	23	15	12	2

Flygt 2102: 8.2HP
150 GPM

VIB-North Mine Ditch

	TPb	DPb	TZn	DZn	TSS
3-17-11	862	57.3	291	265	17.0
3-17DUP	730	58.6	303	263	24.0
4-6-11	131	50.9	250	240	0
6-8-11	1633	48	1136	563	42
6-8Dup	1520	40	968	682	43

150 GPM

VIB-Main Sump INF

	TPb	DPb	TZn	DZn	TSS
3-17-11	73.7	47.4	650	630	0
4-6-11	220	41.6	766	680	8.0
4-6Dup	252	56.1	788	536	5.0
6-8-11	289	30	532	368	4

Peerless 7 Stage:
250HP x 2

VIB-103 Ditch

	TPb	DPb	TZn	DZn	TSS
3-17-11	99.2	59.8	1080	1020	107
4-6-11	63.8	60.9	1170	1140	5.0
6-8-11	54	33	1253	932	1

VIB-50 Shack

	TPb	DPb	TZn	DZn	TSS
3-17-11	147	69.4	956	906	5.0
4-6-11	256	65.3	1110	960	21.0
6-8-11	71	35	1039	550	0

150 GPM

VIB-87V1/V15 Discharge

	TPb	DPb	TZn	DZn	TSS
3-17-11	522	53.0	387	302	22.0
4-6-11	926	54.6	393	286	0
6-8-11	1030	36	449	171	60

VIB-Perch Pond Discharge

	TPb	DPb	TZn	DZn	TSS
3-17-11	71.1	65.2	777	793	0
4-6-11	80.9	65.0	882	881	14.0
6-8-11	72	43	1056	577	1

VIB-V15 Pump

	TPb	DPb	TZn	DZn	TSS
3-17-11	770	61.6	431	388	42.0
4-6-11	3160	43.7	1550	411	0
6-8-11	2280	25	217	35	152

Flygt 2066: 3.6 HP
Flygt 2125: 13 HP

VIB-87V1 Pump

	TPb	DPb	TZn	DZn	TSS
3-17-11	92.9	60.6	316	322	0
4-6-11	75.9	53.2	287	270	0
6-8-11	84	34	239	164	0

Flygt 2102: 8.2 HP

VIB-V10 Sump

	TPb	DPb	TZn	DZn	TSS
3-17-11	143	56.8	578	542	0
4-6-11	138	66.2	702	668	0
6-8-11	1505	43	495	177	56

Flygt 2201: 58 HP

VIB-12W Discharge

	TPb	DPb	TZn	DZn	TSS
3-17-11	Pump Out				
4-6-11	60.9	44.3	7.6	12.7	0
6-8-11	595	30	85	7.9	21

VIB-24 Ditch

	TPb	DPb	TZn	DZn	TSS
3-17-11	66.4	52.9	316	300	0
3-17DUP	62.9	59.5	320	316	0
4-6-11	65.8	64.5	355	312	0
6-8-11	85	37	380	298	1

VIB-12W Pump

	TPb	DPb	TZn	DZn	TSS
3-17-11	Pump Out				
4-6-11	59.9	43.5	7.1	11.7	0
6-8-11	188	26	11	9	21

Flygt 2102: 8.2 HP

VIB-23 DEV Discharge

	TPb	DPb	TZn	DZn	TSS
3-7-11	3450	49.4	1060	241	118
4-6-11	404	45.8	286	216	9.0
6-8-11	3532	37	482	135	13

VIB-23 DEV Pump

	TPb	DPb	TZn	DZn	TSS
3-17-11	164	40.8	200	190	9.0
4-6-11	94.0	38.5	212	201	0
6-8-11	283	32	204	127	53

Flygt 2102: 8.2HP

THE DOE RUN COMPANY

Maggie Hettinger 8-19-2011

APPENDIX B:

VENDOR INFORMATION ON GROUT USED FOR COREHOLE SEALING

This page is blank to facilitate double sided printing.

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

STI 03 - 0.03

H20STOP

Dual component, low density, highly reactive, early strength, water control grout

Uses

Water control in mining and civil applications for cessations of high (3,000 G.P.M. +) leaks, combined with rapid void filling and early strength characteristics.

Advantages

- **Extremely fast reacting**
- **Rapid sealing**
- **High early strength**
- **Will inject into the finest of fractures**
- **Will not wash out**

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture. Store under 80 degrees.

Packaging

55 Gallon Steel Drums

Approvals – On file

Transport

USDOT Unregulated Class 55

Shelf Life

2 Year minimum in unopened containers.

Physical Properties

-20º F (shrinkage)	0% 1 day	ASTM D-2126
Viscosity @ 68º F	200 cps A – Side	300 cps B – Side
Specific Gravity @ 60º F	1.23 A - Side	1.04 B - Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Density (Free Rise)	03 PCF	ASTM D-1622
Compressive	200 psi	ASTM D-1621
Tensile	112 psi	ASTM D-638
Shear	107 psi	ASTM D-732

Sub-Technical, Inc.
363 Mars Valencia Road
Mars, Pennsylvania 16046 U.S.A.
Phone: (724)625-0008 Fax: (724)625-0009
www.sub-technical.com
stisales@sub-technical.com

Always Read MSDS Sheets Prior to USE

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

HYPERFLEX

Single component, low density, flexible, hydrophobic grout.

Uses

Sealing of water and gasses in mining and civil applications. Reacts with moisture to form a flexible closed cell grout.

Advantages

- **Simple application**
- **Adjustable set time with catalyst**
- **Flexible, absorbs movement**
- **Low expansive pressure**
- **"Self injection" into the finest of fractures**

Packaging

55 Gallon Steel Drums
5 Gallon Plastic Containers
5 Gallon Metal Containers
1 Gallon Metal Containers

Approvals

NSF 61-2007 approved for use with potable water.

Transport

USDOT. Unregulated Class 55

Physical Properties

Density	Free rise	2.25 lbs/ft³
Low temp. aging	Confirmed	
-20° F (shrinkage)	0% 1 Day	ASTM D-2126
Viscosity	4000 cps	ASTM D-2126
Specific Gravity @ 60° F	1-30%	A-Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Compressive	25 psi	ASTM D-1621
Shear	171 psi	ASTM C-273
Tensile	30 psi	ASTM D-1623
Elongation	300%	ASTM D-1623

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture.

Shelf Life

2 year minimum in unopened containers.

Caution: Always read MSDS prior to use.

WWW.Sub-Technichal.com

724 625 0008 VOICE 724 625 0009 Fax

APPENDIX C:

STANDARD OPERATING PROCEDURES

This page is blank to facilitate double sided printing.

I. INTRODUCTION

Mine water sumps provide temporary storage for mine water, which results in the settling of solids proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids. This means that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, the accumulated solids could eventually impede pumping. For these reasons, periodic maintenance of the sumps is required to remove accumulated solids.

The process of sump cleaning is referred to as "sump mucking". This involves draining the sump, then mechanically removing the accumulated solids from the sump. This standard operating procedure provides guidelines for monitoring main mine water sumps and determining the need for sump cleanout.

II. MATERIALS

The following materials will be available to monitor mine sumps:

- Personal protective equipment as required by the Health and Safety Plan;
- Light source;
- Depth finding device;
- Tape measure;
- Field log;

III. PROCEDURES / GUIDELINES

All major mine sumps will be cleaned when the accumulated solids exceed 50% of the water depth in the sump at the point of measurement near the pumps. To determine the sump mucking trigger, the following procedures must be adhered to:

A. Depth Measurement

1) A depth finding sonar device will be installed near the pumps at each of the major mine sumps to measure the depth of sediment in the sump.
2) A standard reference mark will be established for each sump, to which the water level can be referenced on a recurring basis.
3) The water level will be determined by measuring from the standard reference mark down to the water level with a tape measure.
4) As an alternative to steps 2 and 3, mine personnel may opt to install a staff gauge in the sump for measuring water level.

B. Inspection

1) During each quarterly inspection, the water level and depth to solids in each sump will be recorded from depth finding device.

C. Documentation

The following information will be recorded:

1) Sump identification/location
2) Sump inspection date
3) Measurement of water level
4) Measurement of depth to sediment in each sump
5) Notification of underground water management team, if the depth of solids is more than 50% of the water depth in the sump
6) Start and end date for sump cleanout and problems encountered

I. INTRODUCTION

Exploration coreholes at the Doe Run Mines are currently sealed by mine personnel. This practice has been in place for many years. New coreholes that are encountered during mining operations and that produce significant flows to the mine will be sealed, if sealing is technically feasible. This standard operating procedure provides a decision framework and guidelines for monitoring and sealing coreholes when they are encountered during mining operations.

II. MATERIALS

The following materials, as required, will be used when coreholes are encountered:

- Any necessary safety equipment;
- 55 gallon drum or other similarly sized container of known volume;
- 5 gallon bucket or similar smaller container;
- Stopwatch;
- Measuring tape;
- Field log;
- Mine map;
- Camera.

III. PROCEDURES / GUIDELINES

When a corehole is encountered during mining operations the following procedures shall be used:

A. Determine flow rate from corehole

1) Flowrate from the corehole will be estimated by measuring the time required to fill a 55 gallon drum or other similarly sized container of known volume.
2) If the location of the corehole prevents the use of a 55 gallon drum or if the flow is too small for filling of a 55-gallon drum to be practical, then a 5 gallon bucket or similar smaller container will be used.
3) If, due to the quantity of flow or for safety reasons, it is not possible to measure the flow, this should be reported to the underground water management team who will determine an alternate flow estimation method.
4) Because flows often change after coreholes are encountered, the flow rate will be measured once per month for three months to obtain a better estimate of its long-term flow.

B. Measure the corehole diameter

1) The diameter of the corehole will be measured to the nearest inch.
2) If it is infeasible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.

C. Determine if sealing is required and feasible

1) If the flow from the corehole exceeds 25 gallons per minute the corehole will be sealed.
2) The underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past.
3) If it is unclear whether sealing is feasible, the underground water management team will consult with manufacturer's representatives for mechanical plugs and grouts to help

determine the feasibility of sealing the corehole.

D. Seal the corehole

If it has been determined that the corehole can be sealed, the underground water management team will determine a schedule for the sealing work and ensure that the work is completed.

E. Documentation

The following information must be recorded in writing and submitted to the underground water manager:

1) Corehole discovery time and date.
2) Location of corehole recorded on map
3) Diameter of corehole
4) Measured flowrate – record procedure and results
5) Determination of sealing requirement
6) Problems encountered with sealing determination
7) Communication with the underground water management team
8) If the corehole cannot be sealed – record the reasons for that determination
9) Methods and procedures of corehole sealing
10) Problems encountered in the sealing process and apparent success
11) Sealing completion time and date.
12) Pictures of the corehole will also be taken and kept with the field log.

APPENDIX D:

UNDERGROUND WATER CONTROL MEASURE INSPECTION FORM

This page is blank to facilitate double sided printing.

Underground Water Management Inspection

Date: ________________________ **Inspection By:**_________________________

Mine: ____

Notes: ____

Sumps

Sump ID/Location	Water Level	Depth to Sediment	Notification Date

Notes: ____

____

____

Piping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

Underground Water Management Inspection

Date: ______________________ **Inspection By:**______________________

Roadways

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

BMPs/General Housekeeping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

EXHIBIT K

UNDERGROUND WATER MANAGEMENT PLAN for the CASTEEL MINE

Prepared for: **The Doe Run Resources Corporation d/b/a The Doe Run Company**

January 10, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1. INTRODUCTION

This document presents the Underground Water Management Plan (UGWMP) for the Viburnum Mine/Mill #35(Casteel), prepared on behalf of the Doe Run Resources Corporation, d/b/a/ The Doe Run Company (DRC). The Casteel UGWMP has been prepared in accordance with the Master UGWMP previously prepared by Resource Environmental Management Consultants, Inc. In keeping with the Master UGWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Casteel Mine is located in Iron County, Missouri, approximately 4 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Casteel Mine (USGS, 2008).

Year	Event
1978	Structures including the head frame and a building containing offices, a change room, and the hoist room were moved from the Viburnum No. 27 mine to Casteel.
1983	Opened for production by the St. Joseph Lead Company. About 80% of ore was trucked to the Central Viburnum Mill and 20% to the Brushy Creek Mill.
1992	Viburnum Mill closed
1995	Viburnum Mill reopened
2001	Viburnum Mill closed
2003	Casteel Mine ceased operation
2004	Casteel Mine resumed operation
2008	Ore trucked to the Buick Mill for processing

The Casteel Mine is the second northernmost active mine in the Viburnum Trend. Mining operations occur approximately 1,000 feet below ground surface.

1.2 OBJECTIVES

As stated above, the main objective of this UGWMP is to evaluate the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility. This main objective is met through the following:

- Understanding of the sources, quantity and movement of water through the mine.

- Understanding of the quality of water entering, moving through, and leaving the mine, with respect to the target constituents of interest.
- Identification and evaluation of potential control measures for reducing water volumes, metals concentrations, or both in the mine.

Each of these items is discussed in this plan. The UGWMP also presents an assessment of the technical feasibility of various potential control measures for the Casteel Mine, as well as a plan for further investigation or implementation of potentially technical feasible control measures, based on whether such measures are likely to reduce metals loading and whether they are cost-effective.

1.3 UNDERGROUND WATER MANAGEMENT TEAM

Underground water management for the Casteel Mine will be the responsibility of the individuals named in Table 1-2.

Table 1-2. Casteel Mine Underground Water Management Team.

Job Title	Name	Contact Information	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	P.O. Box 500 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mine Manager	Greg Sutton	P.O. Box 500 Viburnum, MO 65566 573-626-2001	Oversight and management of Doe Run Mining Operations
Casteel General Mine Supervisor	Randy Arndt	1961 Highway 32 Bixby, MO 65439 573-626-4217 ext. 4411	Casteel UGWMP Primary Oversight, Implementation, and Record-Keeping
Casteel Mine Superintendent	Adam Kresler	1961 Highway 32 Bixby, MO 65439 573-626-4217 ext. 4428	Casteel UGWMP Secondary Oversight, Implementation, and Record-Keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573-689-4535	Environmental data collection, management, and reporting

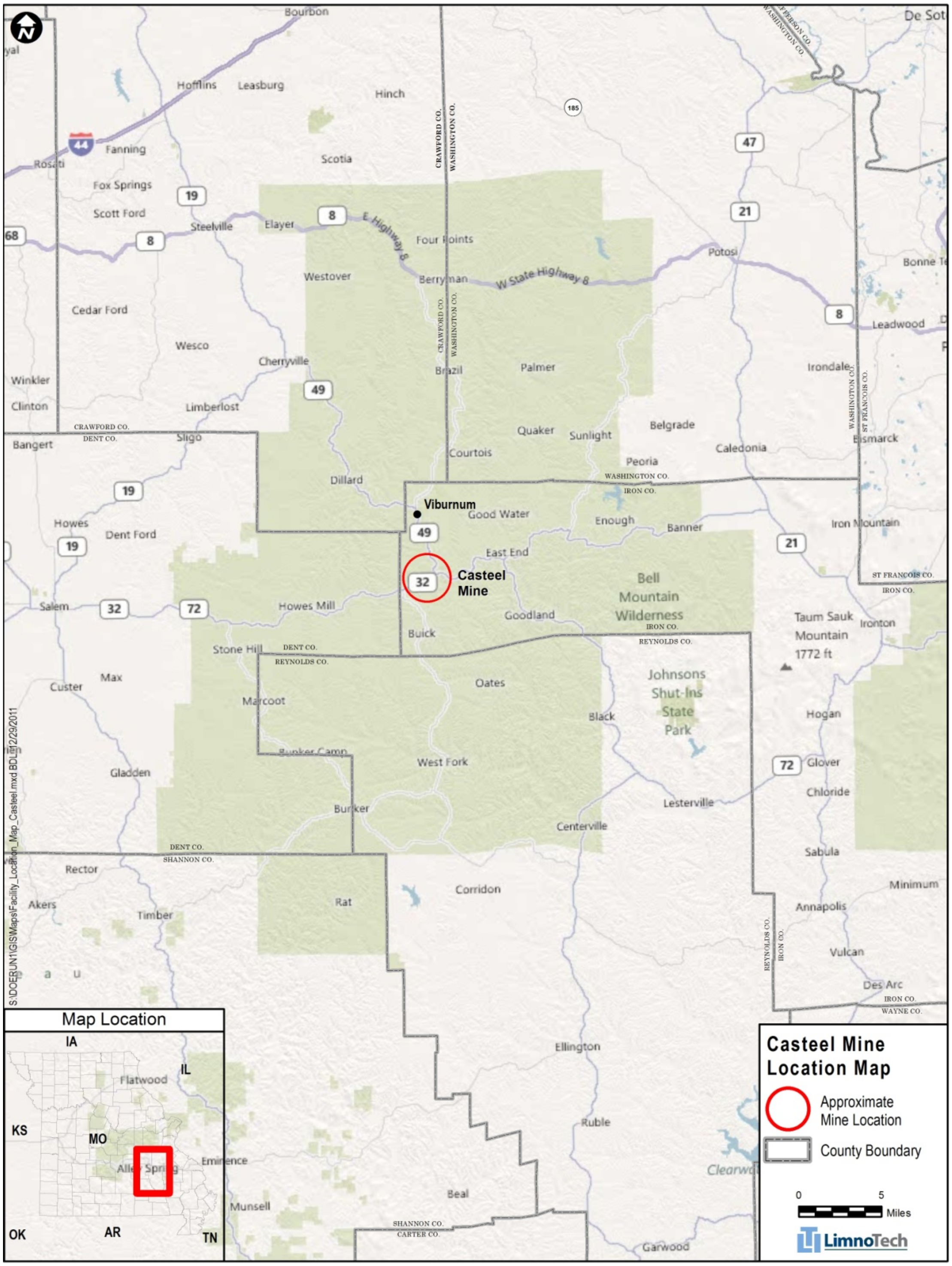


Figure 1-1. Location of the Casteel Mine.

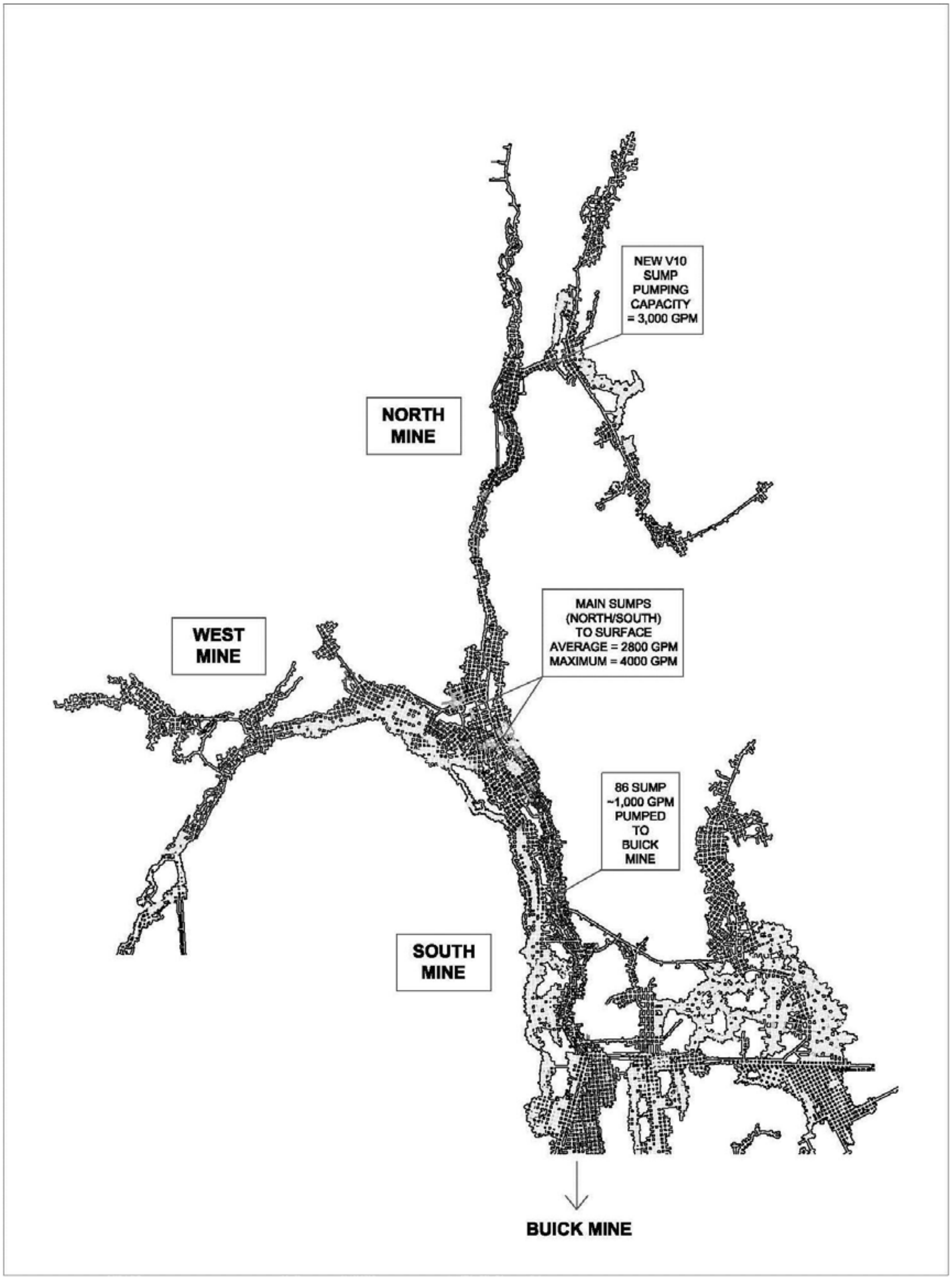


Figure 1-2. Layout of the Casteel Mine.

2. SUMMARY OF MINE WATER DATA

The Master UGWMP outlined the hierarchy of water management priorities listed below from highest priority to lowest.

1. Source Control
2. Water Minimization
3. Reuse or Reclamation
4. Water Treatment
5. Discharge

Because source control has been identified as the first water management priority, source identification is a fundamental part of the planning effort for potential measures to control metals loading. Load is a function of both flow and concentration. Therefore, these components were each examined independently at the Casteel Mine, as described below.

2.1 WATER SOURCES AND MOVEMENT

An inventory of water in the Casteel Mine was compiled for this plan based on the best available information and includes the following components:

- Total mine water flows
- Sources of mine water
- Current underground management of mine water

Each of these components is described below.

2.1.1 Total Mine Water Flows

Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Casteel Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-1.

Table 2-1. Mine Water Flowrates at Casteel Mine.

Quantity	Value
Average Flow Pumped to Surface (current)	3,800 gpm
Maximum Mine Water Pumping Capacity	7,000 gpm

Flow data are not currently recorded at the mine water sump, but are estimated from pump capacities and historical measurements. The average flow reported in Table 2-1 is based on historical data and pump capacities. The maximum pumping capacity is based only on pump capacity and does not reflect maximum flows actually pumped from the mine. It is known that flow rate can vary over time depending on factors such as season or where the mine is being advanced, however the values in Table 2-1 represent the best available estimate.

Construction of a new mine water sump has been completed. This sump, called the V10 sump, became fully operational at the end of February 2012. It is located near the north end of the mine and increased the mine water maximum pumping capacity at Casteel by 3,000 gpm. Currently, Casteel is pumping an average of 2,000 gpm from V10. The flow includes water coming from the north part of Casteel as well as mine water collected at the 86 sump, which was previously pumped to the Buick mine, and is now diverted to the Lower Main Sump after excess capacity was created there by the new V10 sump project.

2.1.2 Sources of Mine Water

Water enters the Casteel Mine mainly through shafts and general seepage. Given the diffused nature of most water entering the mine it is difficult, if not impossible, to accurately measure all sources. However, mine water flows have been estimated by Doe Run personnel at some key locations in the Casteel Mine. The major flow distribution of mine water pumped to the surface at Casteel is as follows:

- Approximately 55% of the total mine water flow at Casteel (approximately 2,100 gpm on average) is from the north mine.
- Approximately 20% of the total mine water flow at Casteel (approximately 700 gpm on average) is from the west mine.
- Approximately 25% of the total mine water flow at Casteel (approximately 1,000 gpm on average) is from the south mine.

This flow distribution is depicted schematically in Figure 2-1.

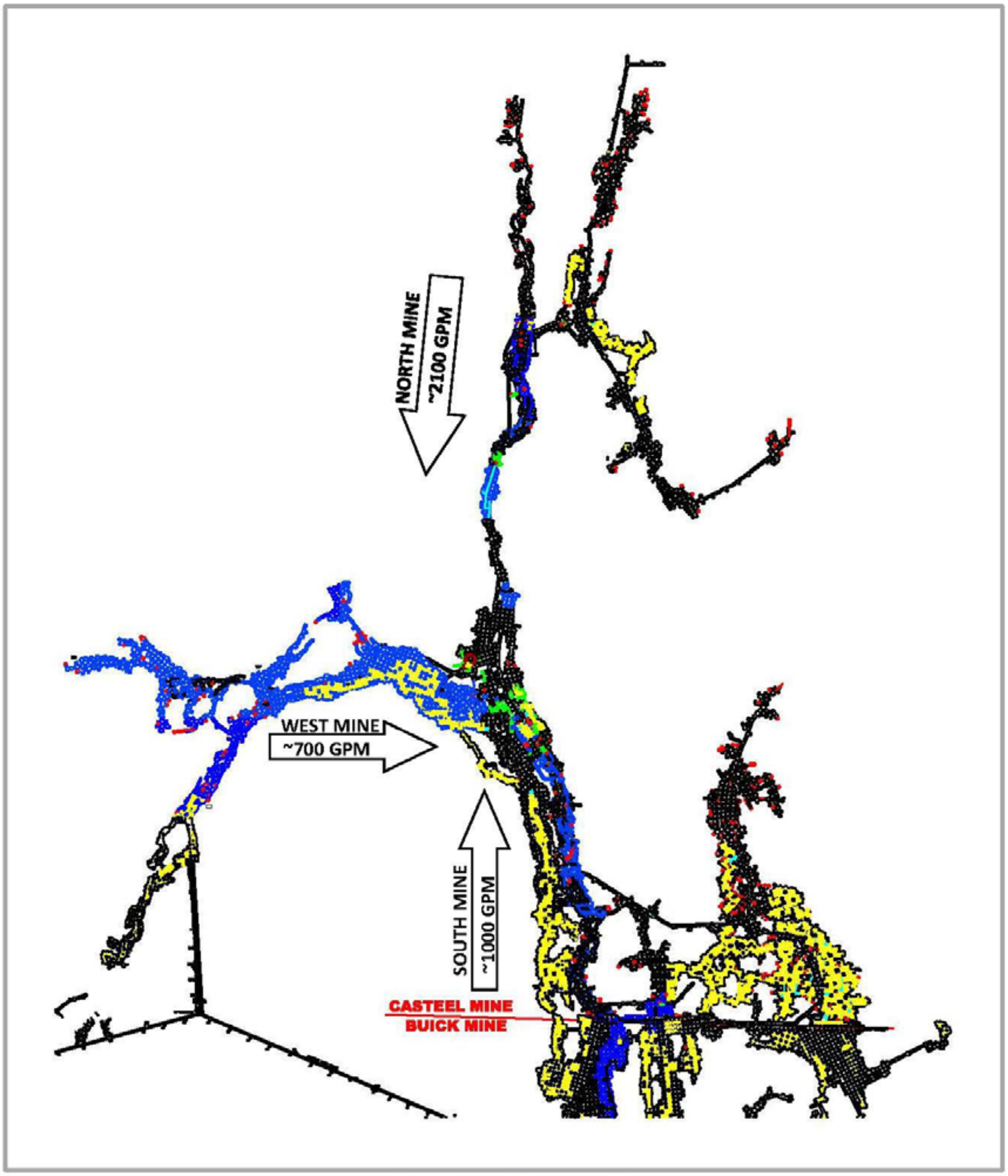


Figure 2-1. Estimated Average Major Mine Water Flows for the Casteel Mine.

2.1.3 Current Underground Water Management Practices

Current practices to manage mine water at Casteel Mine are primarily focused on maintaining safe and workable conditions in the mine and are not specifically designed to maintain or improve water quality. These practices include the following:

- Piping – Piping of water through the mine has historically been performed to facilitate transfer pumping from one location to another, where mine grades prevent gravity flow. Piping is discussed in greater detail in Section 3.1.1.
- Sump cleaning – Sump cleaning, or mucking as it is called by mine personnel, has historically been performed, as needed, to maintain performance of the mine water sump pumps. Sump mucking is discussed in greater detail in Section 3.4.9.

Although it may not be their specific intent, these practices may have an incidental benefit of protecting water quality. These and other potential water management practices to preserve or improve water quality are discussed in greater detail in Section 3 of this Plan.

2.2 MINE WATER QUALITY

To support development of this and other water management plans at Doe Run mine/mill facilities, a water quality sampling program was implemented between December 2010 and June 2011. Three rounds of underground water sampling were performed at each mine. The details of the underground sampling program, including the sampling results, are presented in the Underground Water Sampling and Analysis Plan Report (LimnoTech, August 4, 2011). Sampling locations for these events are shown in Figure 2-2. A more complete map of Casteel Mine showing sample locations, water flow paths, pump information, and sampling results for total and dissolved lead and zinc, is included as Appendix A.

These data were evaluated to better understand mine water quality at Casteel Mine and to discern factors that may improve or degrade mine water quality. Because the purpose of this UGWMP and the surface water management plan at Casteel is to be part of a comprehensive effort above and below ground to attain compliance with Missouri State Operating Permit (MSOP) future final limits for the discharge of mine water and other sources to waters of the State, the mine water data were evaluated in reference to the future final discharge limits in the MSOP for the Casteel Mine. The limits for the primary constituents of interest for outfalls 001 and 003 are summarized in Tables 2-2 and 2-3, respectively.

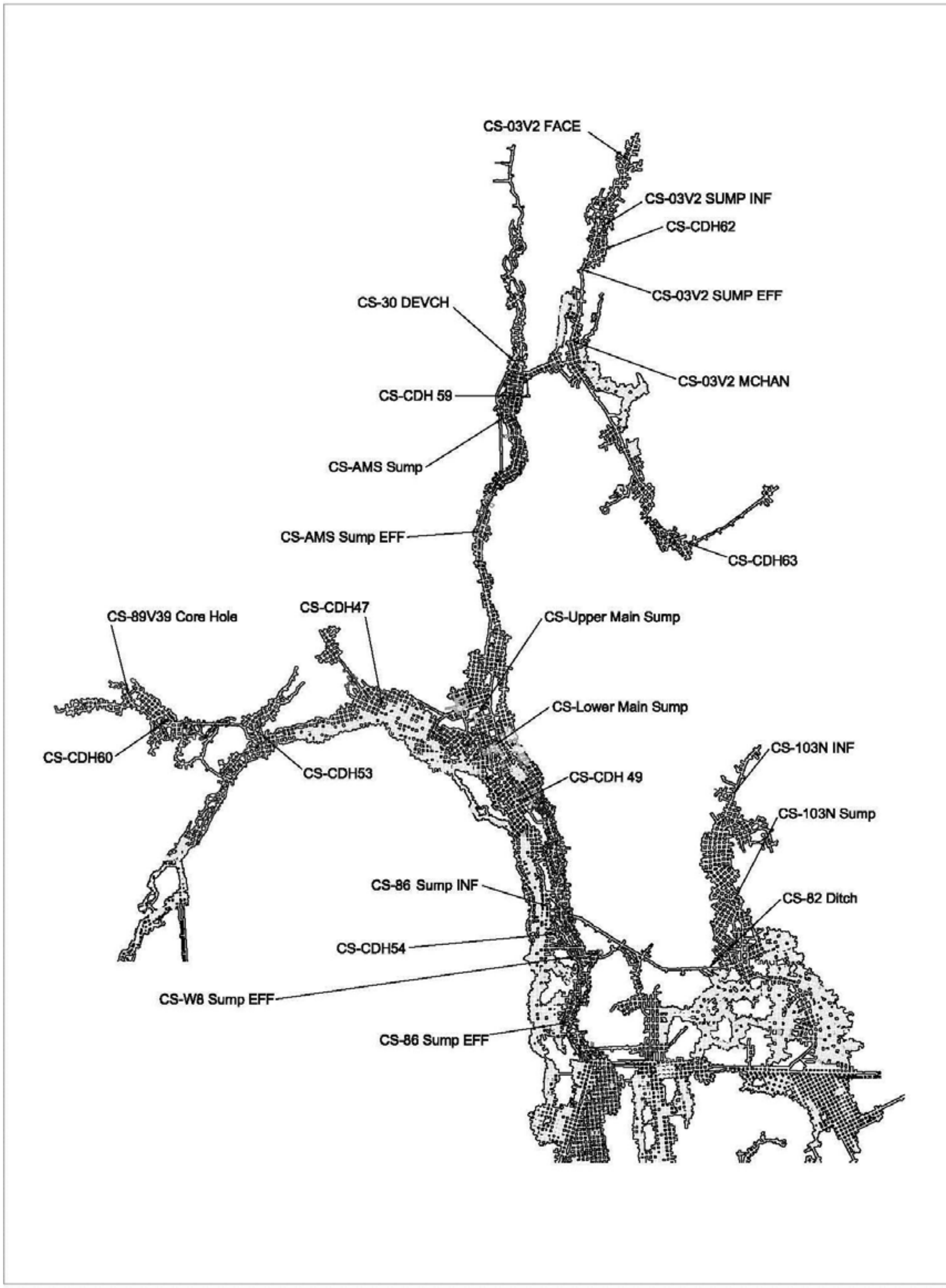


Figure 2-2. Mine Water Sampling Locations for the Casteel Mine.

Table 2-2. Future Final MSOP Limits for the Casteel Mine (Outfall 001).

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.6	0.8
Copper, total recoverable	300	150
Lead, total recoverable	48.2	24
Zinc, total recoverable	446.3	222.4

Table 2-3. Future Final MSOP Limits for the Casteel Mine/Mill Facility (Outfall 003).

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.2	0.6
Copper, total recoverable	137.2	68.4
Lead, total recoverable	59.4	29.6
Zinc, total recoverable	468.1	233.3

The findings of this evaluation are presented in the following sections.

2.2.1 Incoming Mine Water Quality

Incoming mine water quality at Casteel Mine is characterized by samples collected at locations 30 DEVCH, 89V39 Core Hole, CDH47, CDH49, CDH53, CDH54, CDH59, CDH60, CDH62, and CDH63. The sample 30 DEVCH represents the channel flowing from the 30 development area in the northern part of the mine. The 89V39 Core Hole sample is located at the 89V39 Core Hole in the west mine. The samples denoted by "CDH" represent vent shaft influent samples.

Three samples and one duplicate from 30 DEVCH, two samples from CDH53, and one sample from each of the remaining incoming mine water samples were taken during the underground water sampling program. The data are presented in table 2-4. The duplicate sample at 30 DEVCH is denoted with a “9.”

Comparing these results to the future final discharge limits presented in Tables 2-2 to 2-3 shows that, in general, concentrations of primary metals in incoming mine water are generally below the future final permitted discharge limits. The only exceptions are total cadmium and copper at 30 DEVCH and lead concentrations at 30 DEVCH, CDH47, and CDH53. It should be noted that the higher metals concentrations seen in the samples from 30 DEVCH and 89V39 Core Hole are likely attributable to the exposure of the incoming mine water to mine workings prior to sample collection. It is expected that incoming mine water is more accurately represented by the samples from CDH47, CDH49, CDH53, CDH54, CDH59, CDH60, CDH62, and CDH63 and that incoming mine water at other locations may have similar quality. It should be noted, however, that the quality of incoming mine water may vary depending on the rock strata through which it flows before entering the mine. Therefore it is not certain that all water entering the mine will have the same quality as is reflected in these samples.

Table 2-4. Incoming Mine Water Quality at Casteel Mine.

Location	**Sampling Date**	**Parameter**				
		Total Cadmium (μg/L)	Total Copper (μg/L)	Total Lead (μg/L)	Total Zinc (μg/L)	TSS (mg/L)
30 DEVCH	3/7/2011	1.7	24.2	400	165	ND (5)
30 DEVCH	3/30/2011	0.51	11.2	26.9	57.3	ND (5)
9-30-DEVCH	3/30/2011	0.5	10.6	28.4	54	ND (5)
30 DEVCH	6/9/2011	0.04	ND (0.97)	15	7.4	ND (5)
89V39 Core Hole	3/7/2011	ND (0.08)[1]	0.53	1.5	11.6	ND (5)
CDH47	3/7/2011	0.2	20.8	176	16.8	79
CDH49	3/7/2011	ND (0.08)	18.4	1.9	ND (5)	ND (5)
CDH53	3/7/2011	ND (0.08)	9.3	75.8	ND (5)	ND (5)
CDH53	3/30/2011	ND (0.08)	3.2	11.9	ND (5)	5
CDH54	3/7/2011	ND (0.08)	1.9	0.82	ND (5)	ND (5)
CDH59	3/7/2011	ND (0.08)	ND (0.5)	1.8	ND (5)	ND (5)
CDH60	3/7/2011	0.94	1.5	2.5	5	ND (5)
CDH62	3/7/2011	ND (0.08)	ND (0.5)	0.28	ND (5)	ND (5)
CDH63	3/7/2011	ND (0.08)	ND (0.5)	0.29	5.7	54

[1] ND indicates that the parameter was not detected at the analytical detection limit shown in parentheses.

2.2.2 Comparison of Incoming and Outgoing Mine Water

Inspection of the water data collected throughout Casteel Mine shows that samples at many locations contain concentrations of target metals above the future final permitted effluent limits, so incoming and outgoing mine water (i.e., mine water pumped to the surface) were compared to discern which of those metals exceed their respective future final discharge limits.

These comparisons of samples taken of incoming mine water at 30 DEVCH, 89V39 Core Hole, CDH47, CDH49, CDH53, CDH54, CDH59, CDH60, CDH62, and CDH63 with mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-3, 2-4, 2-5, and 2-6, respectively. As stated above, incoming mine water quality is characterized by samples collected at 30 DEVCH, 89V39 Core Hole, CDH47, CDH49, CDH53, CDH54, CDH59, CDH60, CDH62, and CDH63. Outgoing mine water is characterized by samples collected at Lower Main Sump and Upper Main Sump. Three samples were collected at each of these locations in the underground sampling program and an additional eight samples were collected from January to August 2012. The following observations can be made from the data shown in Figures 2-3, 2-4, 2-5, and 2-6:

- Cadmium: With the exception of one sample from 30 DEVCH, which was exposed to mine workings prior to collection, the only other sample of incoming mine water that exceeds any cadmium future final effluent limit is the March 7 sample from CDH60, which slightly exceeds average monthly limits for both outfalls. Future final monthly average limits are exceeded in all mine water sump samples and future final daily maximum limits are exceeded in half of the mine water sump samples.

- Copper: All samples of incoming mine water are well below the future final effluent limits for copper. With the exception of the Lower Main sump sample collected on March 30, which slightly exceeds the future final monthly average copper limit for Outfall 003, all sump samples are below future final effluent limits.

- Lead: Aside from samples collected from 30 DEVCH, which were exposed to mine workings prior to collection, two incoming mine water samples, collected at CDH47 and CDH 53, exceeded the future final effluent limits for lead. It should be noted that a subsequent sample collected at CDH53 did not exceed future final limits. Most mine water sump samples exceeded the future final monthly average and daily maximum limits for lead.

- Zinc: None of the incoming mine water samples at Casteel exceeded future final effluent limits for zinc and only one mine water sump sample exceeded future final zinc limits (the Lower Main sump sample collected on March 30 exceeded monthly average zinc limits).

These results suggest that exposure of mine water to the mine workings at Casteel can result in significant degradation of water quality, in part likely due to the increase in total suspended solids. The relationship between increased metals concentrations and increased suspended solids in mine water is discussed in Section 2.2.4 of this plan.

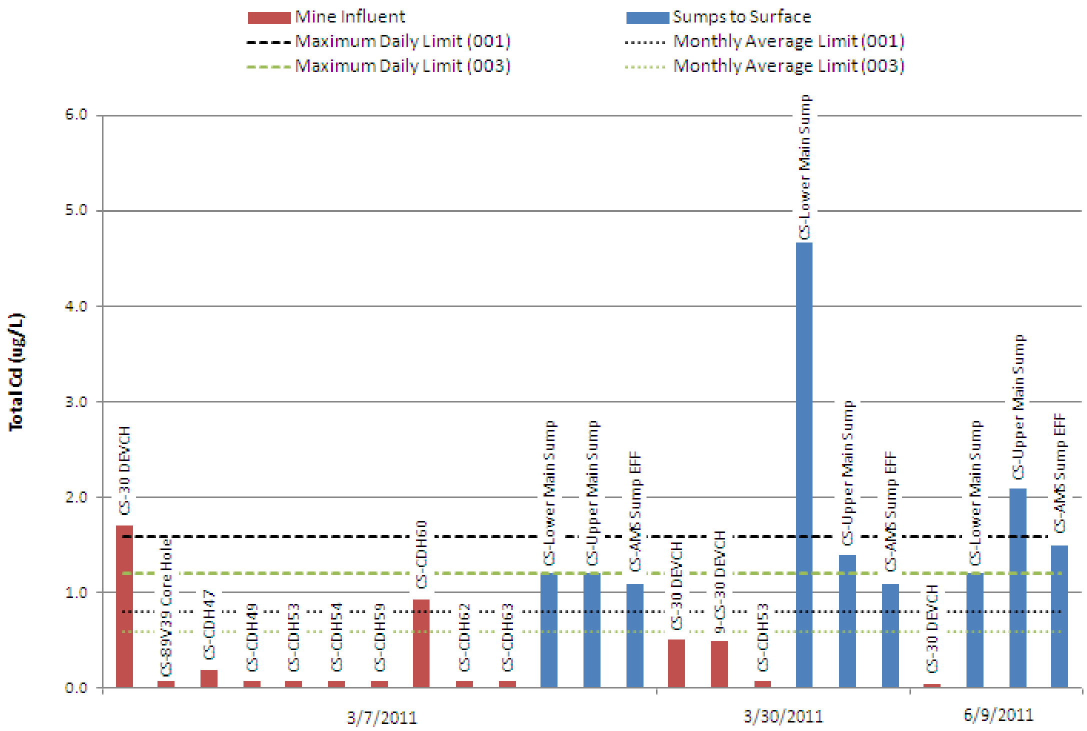


Figure 2-3. Incoming vs. Outgoing Mine Water Quality at Casteel Mine: Total Cadmium.

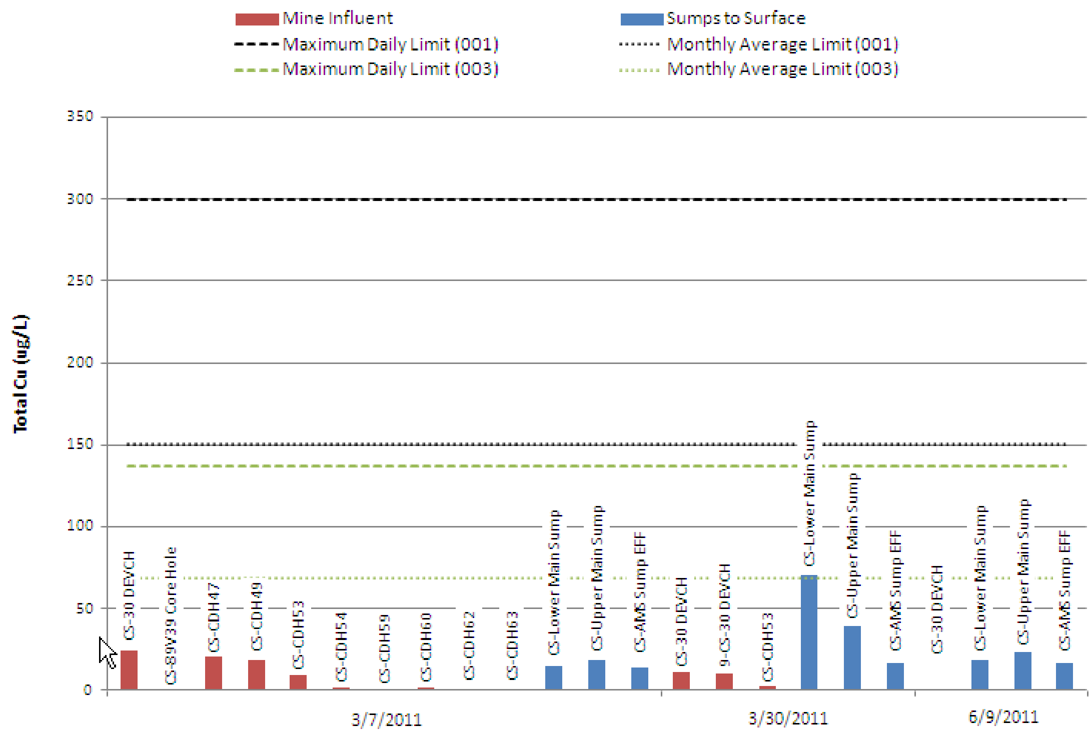


Figure 2-4. Incoming vs. Outgoing Mine Water Quality at Casteel Mine: Total Copper.

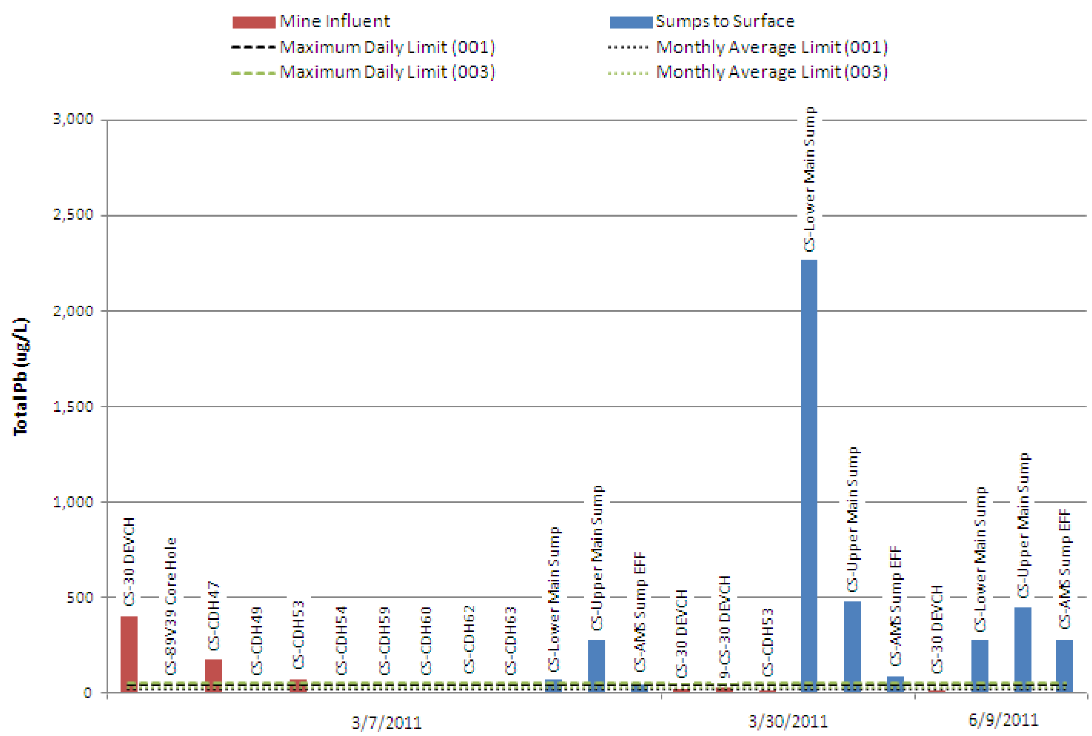


Figure 2-5. Incoming vs. Mine Water Quality at Casteel Mine: Total Lead.

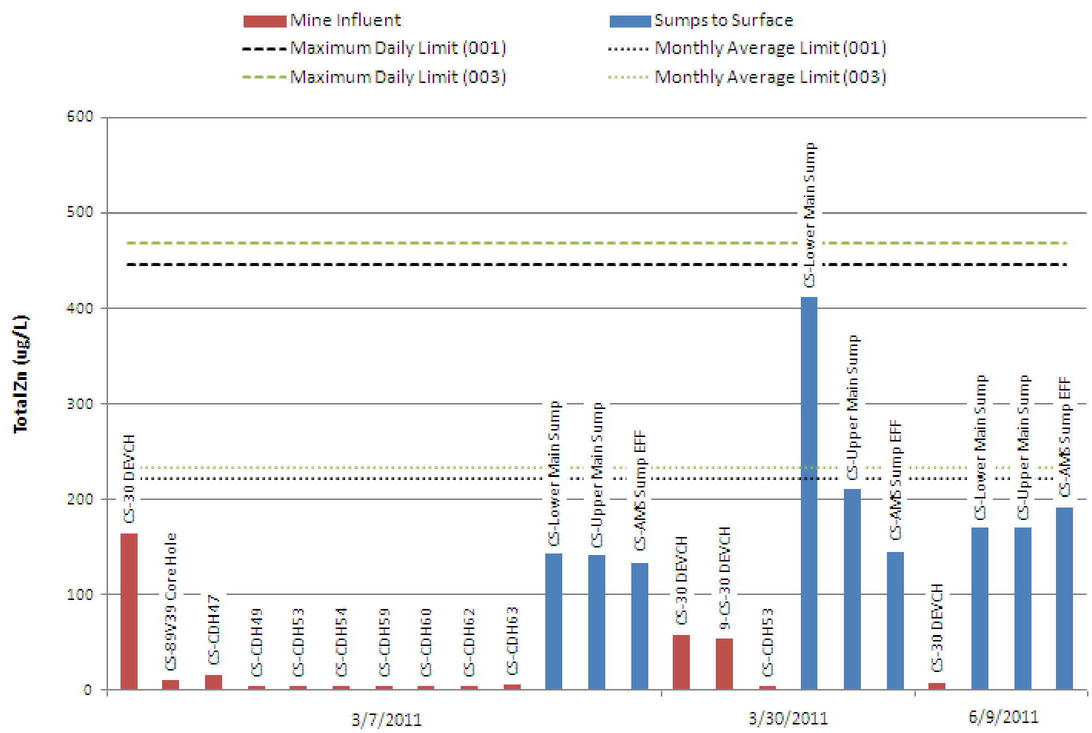


Figure 2-6. Incoming vs. Mine Water Quality at Casteel Mine: Total Zinc.

2.2.3 Spatial Variation in Mine Water Quality

Mine water from the north end of Casteel mine flows south to the Upper and Lower Main sumps, with the Lower Main sump handling most of the flow. Mine water from the west mine flows to the Lower Main sump. Mine water in the southern part of Casteel mine flows to the 86 sump, which is currently pumped to Buick mine.

Most of the mine water that is currently pumped to the surface at Casteel comes from the north. However, although the north mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the three parts. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the north, west, and south were compared. The north mine sampling locations include 03V2 FACE, 03V2 MCHAN, 03V2 SUMP EFF, 03V2 SUMP INF, AMS Sump, and AMS Sump EFF. The south mine sampling locations include 103 N INF, 103 N Sump, 82 Ditch, 86 Sump EFF, 86 Sump INF, W8 Sump EFF, and the Lower Main Sump. The west mine sampling location was at the Upper Main Sump[2]. The results of this comparison are shown in Figures 2-7 through 2-10. Figures 2-7 through 2-10 compare box plots of the mine water quality between the north, south, and west parts of Casteel mine. The box plots can be interpreted as follows:

[2] The four sampling locations in the west mine were determined to be representative of incoming water quality. For purposes of this comparison, samples from the Upper Main Sump were used to characterize water from the west mine.

- The dash in the center of each box represents the median value of the data set.
- The lower and upper edges of the box are the first and third quartiles (the first quartile represents the value that is equal to or greater than 25% of the data and the third quartile represents the value that is equal to or greater than 75% of the data), respectively.
- The lower and upper whiskers are the 5th and 95th percentile values.

For ease of comparison, each plot also shows the future final effluent limits for that metal in the MSOP. The following observations can be made from these plots:

- Cadmium: Cadmium tends to occur at slightly, but perhaps not significantly, higher concentrations in the north mine than in the west and south mines. The lowest concentrations of cadmium occur in the south mine. Overall, samples tended to exceed the monthly average future final effluent limits and lie within or above the daily maximum future final limits.
- Copper: Copper tends to occur at similar concentrations in all parts of the mine. However the range of copper concentrations in the south mine spans four orders of magnitude. For all parts of the mine, means lie within or below the range of the monthly average future final effluent limits.
- Lead: Concentrations of lead in mine water samples used in this comparison (which excludes incoming mine water) exhibit similar mean concentrations in all parts of the mine and generally exceeded the daily maximum and monthly average future final effluent limits.
- Zinc: Zinc appears to occur at slightly higher concentrations in the north mine than in the south and west mines; concentrations in the west mine were lowest. For all parts of the mine, means lie within or below the range of the daily maximum and monthly average future final effluent limits.

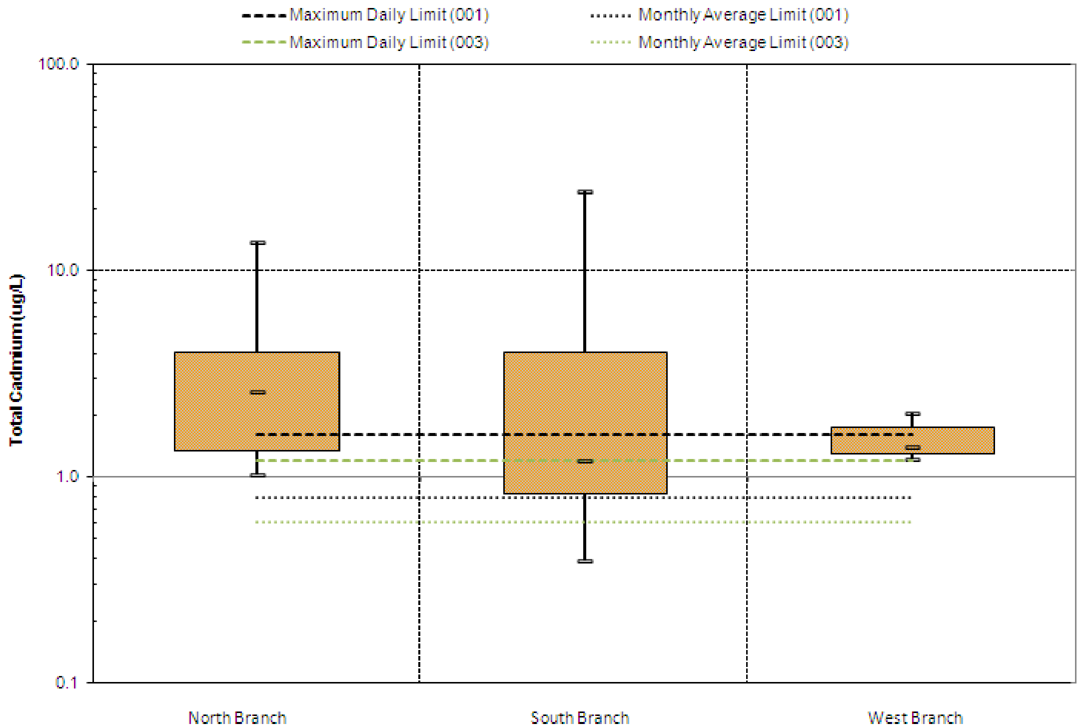


Figure 2-7. Comparison of Total Cadmium between North, South, and West Parts of Casteel Mine.

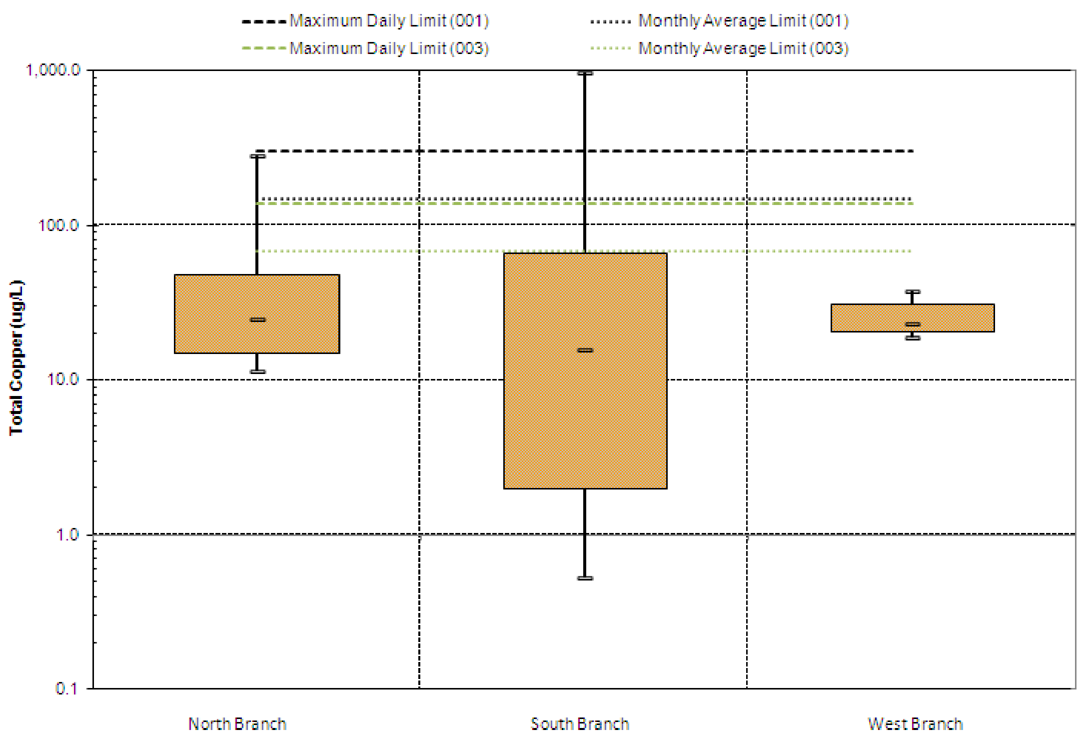


Figure 2-8. Comparison of Total Copper between North, South, and West Parts of Casteel Mine.

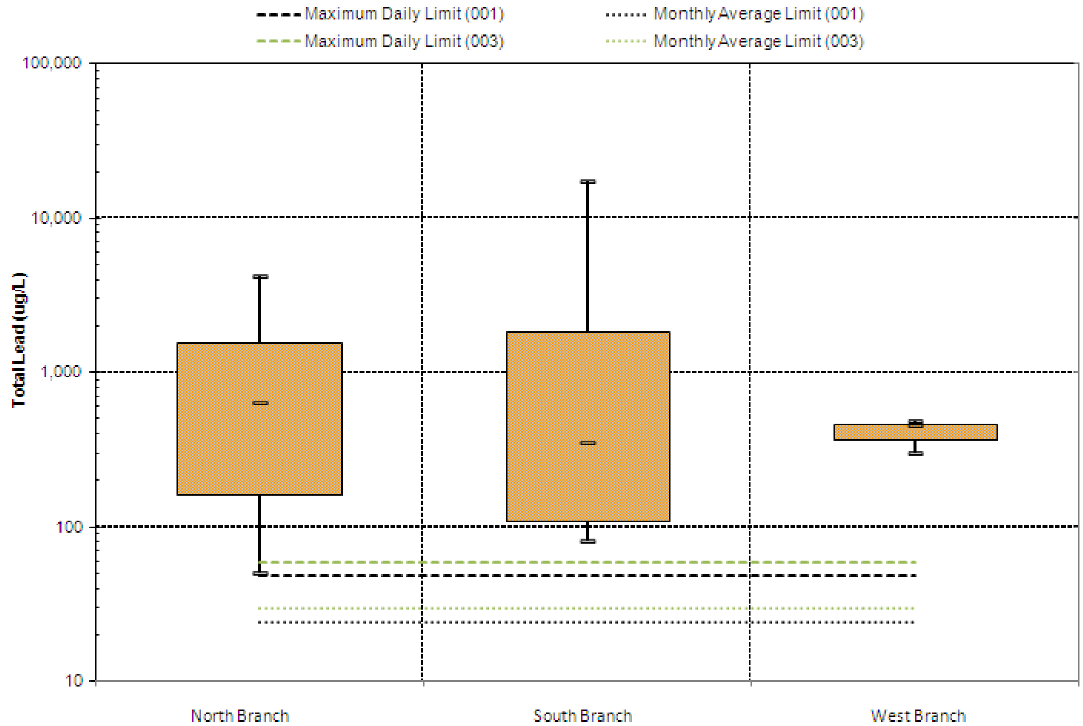


Figure 2-9. Comparison of Total Lead between North, South, and West Parts of Casteel Mine.

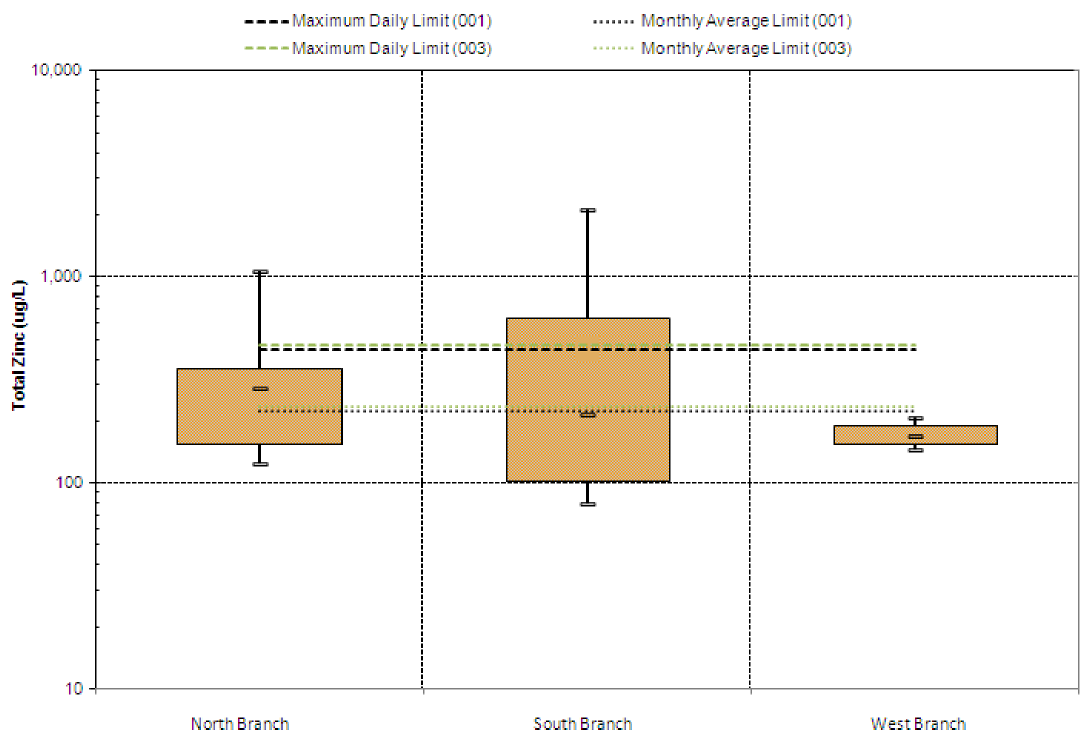


Figure 2-10. Comparison of Total Zinc between North, South, and West Parts of Casteel Mine.

It should be noted that the four sampling locations in the west mine were determined to be representative of incoming water quality and therefore limit the spatial comparison of mine water quality. For purposes of this comparison, samples from the Upper Main Sump were used to characterize water from the west mine. However since the Upper Main Sump also receives water from the north mine, it is not truly representative of the west mine. Nonetheless, based on these comparisons, mine water in the three parts of Casteel Mine is not strongly differentiated with respect to cadmium, copper, lead or zinc.

2.2.4 Relationship Between Solids and Metals in Mine Water

Data from the Casteel Mine show that incoming mine water has moderate metals concentrations compared to mine water that is pumped to surface and that the concentrations are significantly increased by exposure to the mine workings (Section 2.2.2). Therefore, the Casteel Mine data were evaluated to assess the relationship between metals and suspended solids. Figures 2-11 through 2-14 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS).

These results show varying relationships of metals with TSS at Casteel mine. The correlations are summarized in Table 2-5.

Table 2-5. Correlations of Total Metals with Total Suspended Solids at Casteel Mine.

Parameter	Correlation with TSS (r^2 value)
Cadmium, Total	0.52
Copper, Total	0.73
Lead, Total	0.79
Zinc, Total	0.43

The r-squared values[3] in Table 2-5 indicate that total copper and total lead are more closely correlated to TSS than cadmium or zinc. This suggests that increases in TSS, resulting from exposure of incoming mine water to mine workings, are a leading contributor to increases in copper and lead at Casteel. TSS does not appear to affect concentrations of cadmium or zinc as strongly.

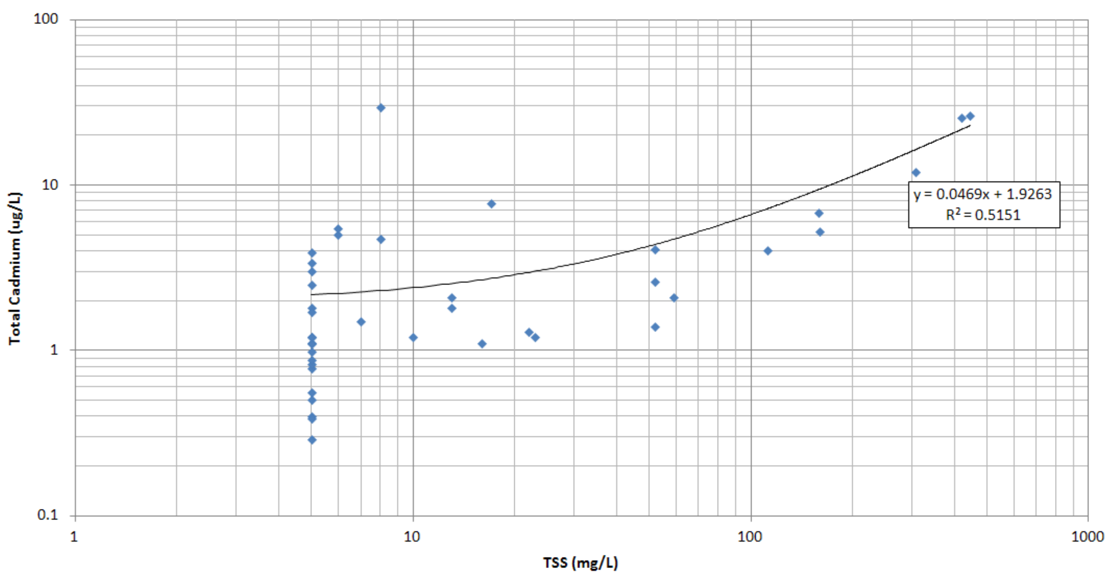


Figure 2-11. Correlation of Total Cadmium with Total Suspended Solids at Casteel Mine.

[3] One way of interpreting r^2 values is that if total copper has an r^2 value of 0.73 with TSS, then TSS explains 73% of the variability of total copper in the data set.

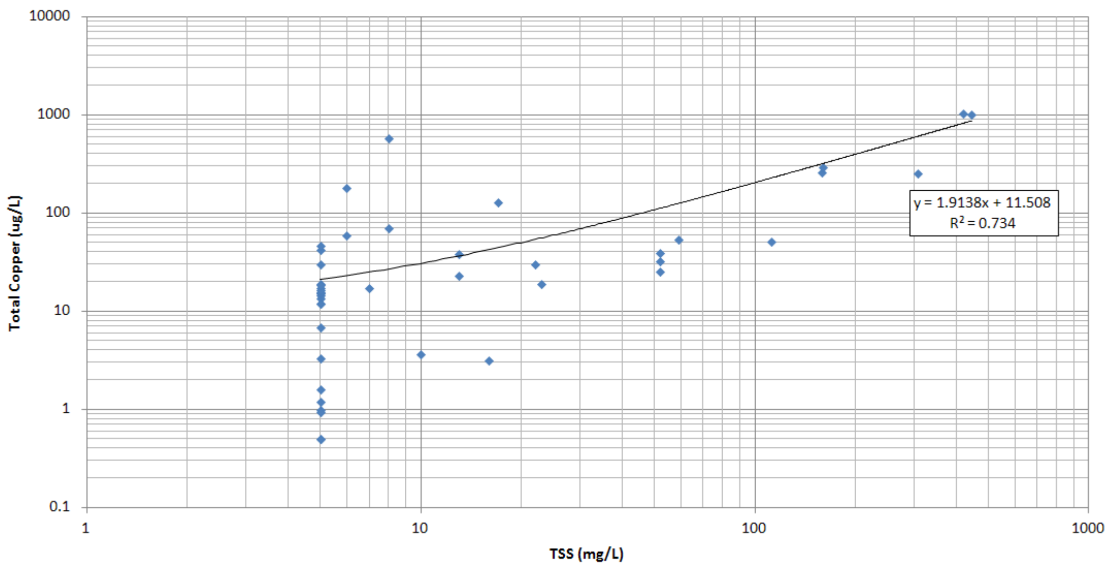


Figure 2-12. Correlation of Total Copper with Total Suspended Solids at Casteel Mine.

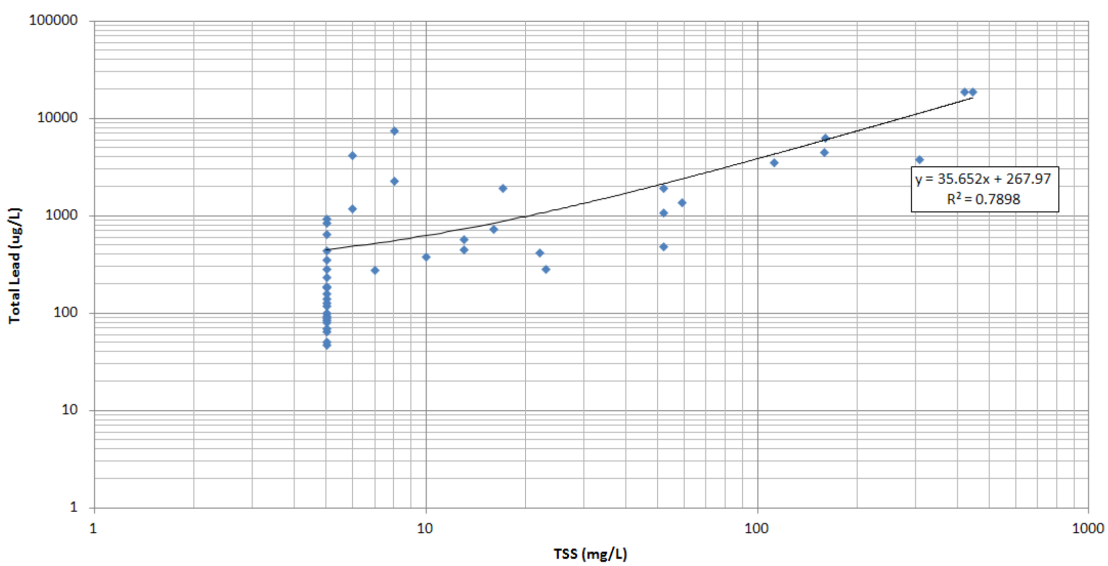


Figure 2-13. Correlation of Total Lead with Total Suspended Solids at Casteel Mine.

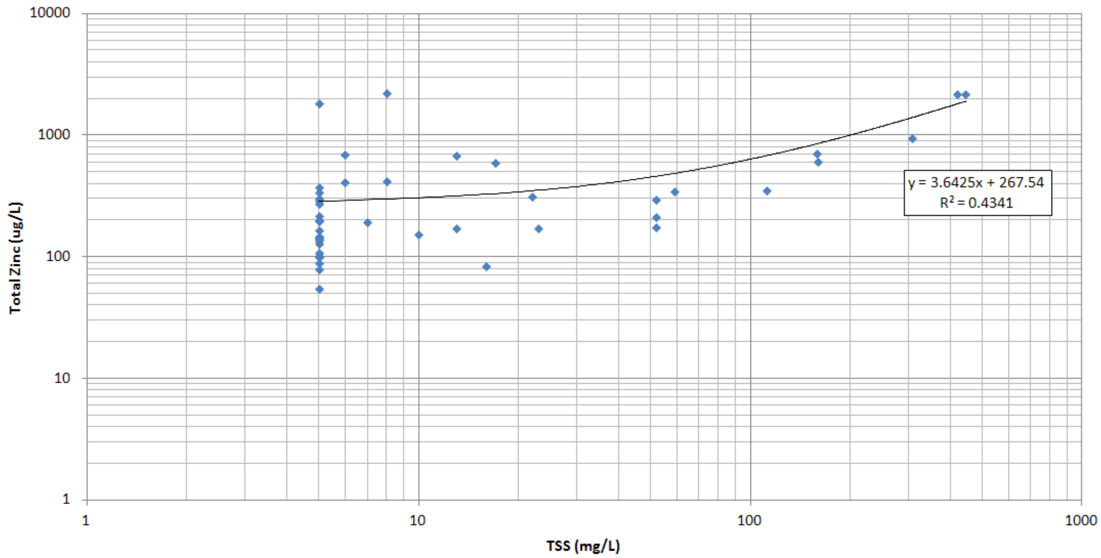


Figure 2-14. Correlation of Total Zinc with Total Suspended Solids at Casteel Mine.

2.2.5 Comparison of Underground and Surface Mine Water

Mine water data at the underground sump at Casteel were compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. Mine water data at the surface is represented by the samples taken at the mine water basin outfalls, 001 and 003. The results are plotted in Figures 2-15 through 2-18 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is not possible because the underground and surface samples were not collected on the same dates in every case and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made. The results indicate that, in general, total cadmium, copper, lead, and zinc are slightly higher in the underground mine water samples collected at the lower and upper main sumps than in the surface mine water samples. Specific observations are as follows:

- Cadmium in the mine water sumps exceeds the monthly average future final limits in all samples and the daily maximum future final limits in half the samples. Cadmium in mine water at the surface exceeds the monthly average future final limits in all four samples shown. Cadmium in mine water at the surface does not exceed daily maximum future final limits.
- Copper in both mine water sump samples and surface mine water samples is below the daily maximum future final limits for every sample. The monthly average future final limit for outfall 003 is slightly exceeded in one of the four samples.
- Lead appears to be slightly lower in most surface mine water samples than in the sump samples. Monthly average and daily maximum future final limits for

lead at outfalls 001 and 003 are exceeded by each incoming mine water sample and by each mine water sump sample.

- For the most part, there is little discernible difference in zinc concentrations between sump samples and surface mine water samples. Zinc in incoming mine water is below monthly average and daily maximum future final limits in all incoming mine water samples and in five of the six mine water sump samples.

Ongoing sampling at Casteel will include underground and surface mine water and these data will continue to be evaluated as they become available.

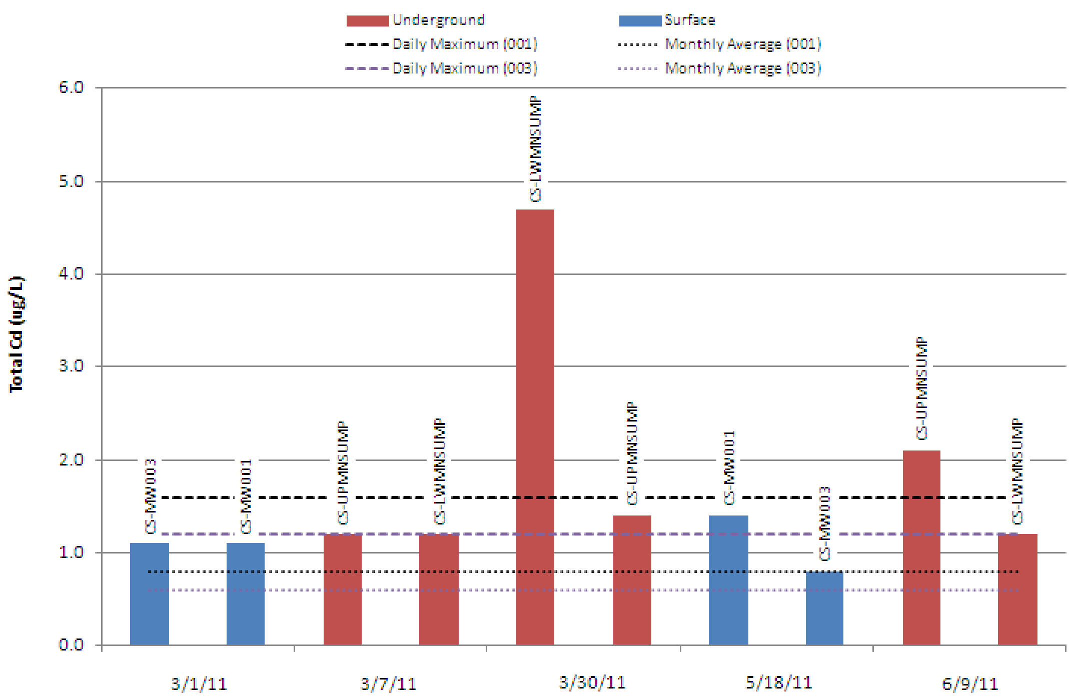


Figure 2-15. Total Cadmium in Underground vs. Surface Mine Water at Casteel Mine.

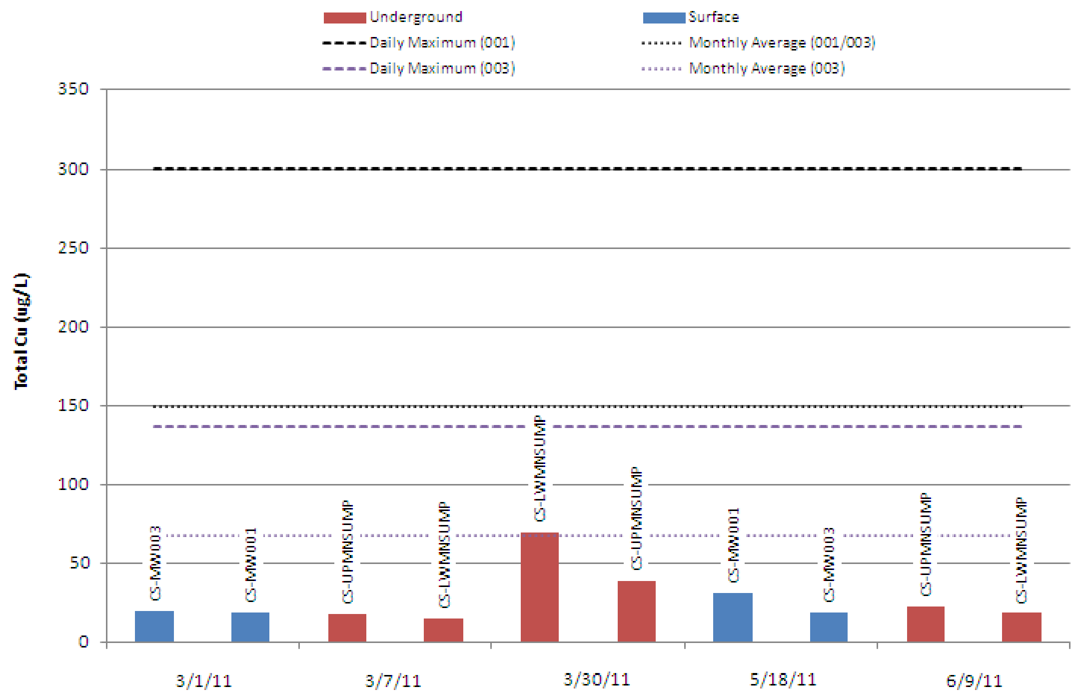


Figure 2-16. Total Copper in Underground vs. Surface Mine Water at Casteel Mine.

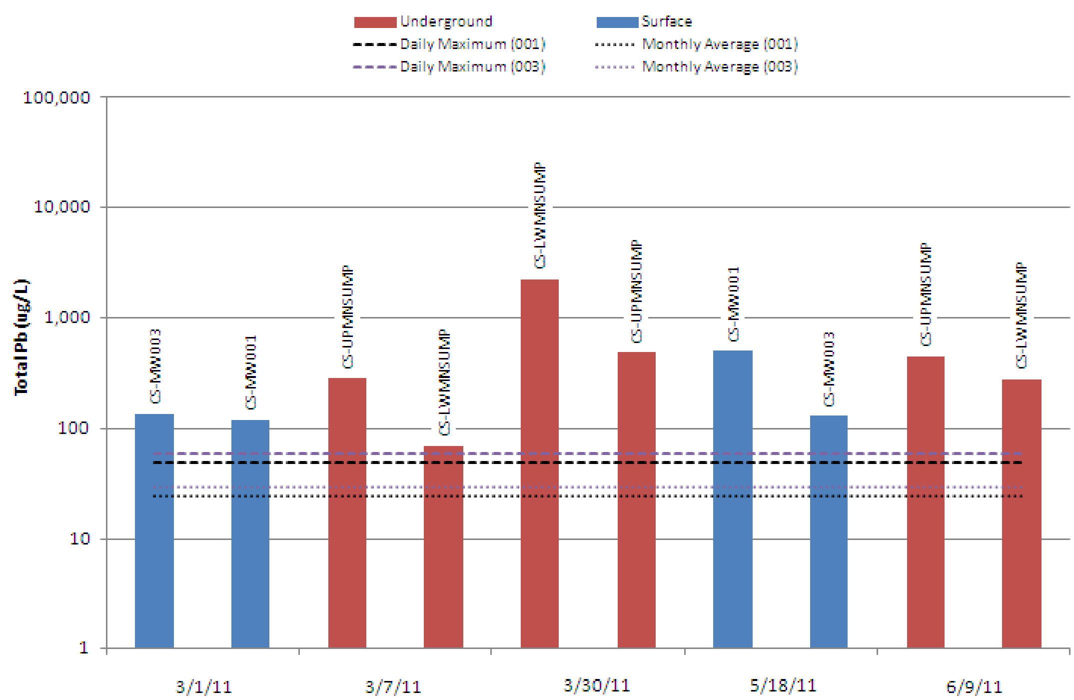


Figure 2-17. Total Lead in Underground vs. Surface Mine Water at Casteel Mine.

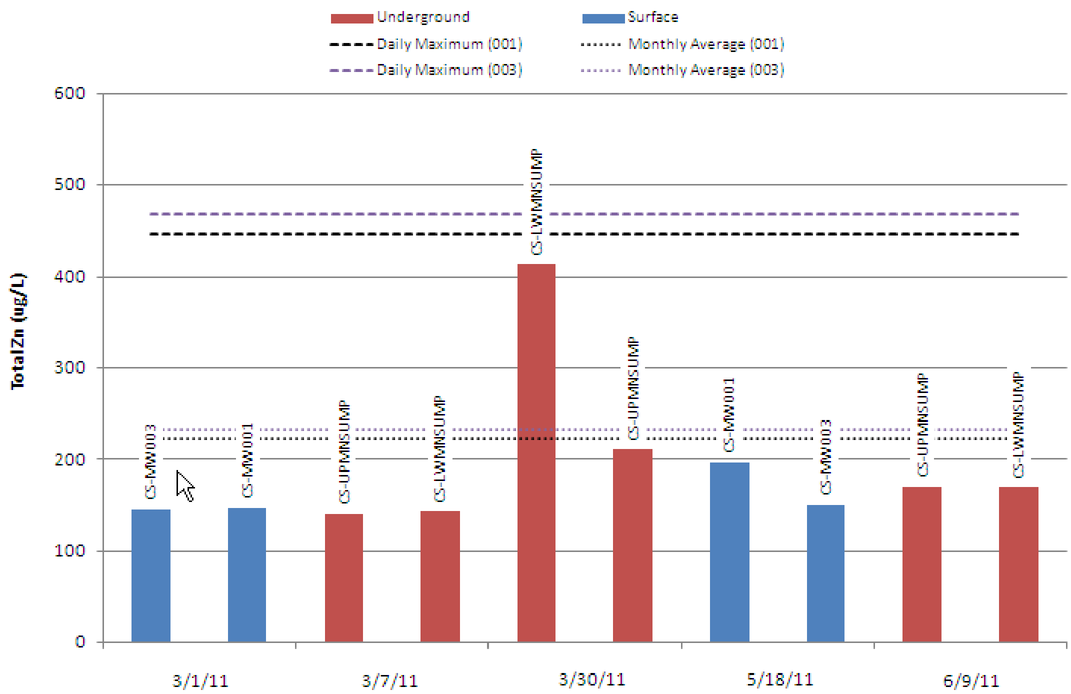


Figure 2-18. Total Zinc in Underground vs. Surface Mine Water at Casteel Mine.

2.3 SUMMARY OF MINE WATER SOURCES AND CONDITIONS

The findings of the preceding discussion of mine water at Casteel Mine can be summarized as follows:

- The average flow of water entering Casteel Mine and being pumped to the surface is estimated at 2,800 gpm.
- Of this total mine water flow, approximately 55% of the flow comes from the North part of the mine.
- Construction of a new mine water sump at Casteel has been completed and became operational in February 2012, which increased the capacity in the existing Lower Main sump. This, in turn, has allowed the diversion of the majority of the mine water previously pumped to Buick mine back to the Lower Main sump in Casteel Mine.
- Incoming mine water has moderate metals concentrations, and exposure to the mine workings increases those concentrations.
- Increased suspended solids in mine water appear to increase total lead and total copper, but does not affect total cadmium and total zinc as strongly.
- In general, concentrations of copper and zinc in mine water at Casteel do not exceed future final effluent limits, whereas concentrations of cadmium and lead generally do exceed future final limits.

- Overall, mine water data collected to date do not indicate pronounced differences in mine water quality between the various parts of the mine.

Some possible water management approaches for Casteel mine for consideration as a result of these findings, include:

- Evaluate the effectiveness, technical feasibility and cost-effectiveness of measures that minimize exposure of water entering the mine to mine workings.
- Evaluate options that are effective, technically feasible and cost-effective to minimize the introduction of suspended solids to mine water in an effort to reduce total lead concentrations.

These water management approaches were used to evaluate potential water management measures, as discussed in Section 3.

This page is blank to facilitate double sided printing.

3. WATER MANAGEMENT MEASURES

This section of the plan presents several potential water management strategies and evaluates them in the context of Casteel Mine. In keeping with the Master Underground Water Management Plan, this section discusses the following types of possible measures:

- Isolation measures (Section 3.1)
- Treatment measures (Section 3.2)
- Groundwater interception (Section 3.3)
- Best management practices (Section 3.4)

A summary of the evaluation of these measures for Casteel Mine is presented in Section 3.5. It should be noted that this Section discusses potential underground water management measures and that these measures are not necessarily all planned for implementation at Casteel Mine. Section 4 describes which of these measures are planned for implementation and further evaluation of their effectiveness, technical feasibility, and cost-effectiveness at Casteel Mine. It should also be noted that Doe Run is currently evaluating the technical feasibility and probable costs of treating mine water at the surface and these evaluations will provide a point of comparison with potential underground water management measures to evaluate the cost-effectiveness of those measures.

3.1 ISOLATION MEASURES

Isolation measures are practices designed to isolate mine water from materials/processes that have the potential to increase metals in the mine water. The objective of isolation technologies is to eliminate or reduce the potential for mine water to contact or be exposed to environments that have the potential to increase the metals load.

3.1.1 Piping Water

In many locations in the mine, mine water flows via gravity in roadside ditches. In some places in Casteel Mine, where it is necessary to pump water due to grade changes, the water flows through pipes. In areas where there is open water in ditches and piping is not used, the water surface is exposed to loading of solids and metals from the roadways, mobilized by passing trucks and machinery. Because of this potential exposure, piping presents a potential control measure for improving water quality.

Parts of Casteel Mine that are currently piped are shown on the map in Appendix A. Piping used in the mine typically consists of high density polyethylene (HDPE) pipe, with 8-inch and 10-inch diameter (nom.) being the most common size used for long runs at Casteel. The unit cost for these pipe materials ranges from $7 to $10 per linear foot (l.f.) for 8” pipe and $11 to $17 per l.f. for 10” pipe. These are materials costs based on current vendor pricing and do not include labor for installation.

Review of sampling data from Casteel and other Doe Run mines shows that water quality is reduced within a short distance of water entering the mine. This suggests that, for piping to be an effective control measure, water must be captured very close to the source before significant exposure to mine workings occurs. This is not possible in every circumstance. However, piping may be implemented on a localized basis at the Casteel Mine as a water quality management measure where the company determines that the measure will be effective in controlling water quality and will be cost-effective.

3.1.2 Lined Channels

Roadside channels in the mine allow contact between flowing water and the underlying rock. This contact may cause an increase in metals concentration, so lining of the channels was evaluated. Lining would involve placement and anchoring of an impermeable material on the bottom of the ditch to prevent the water-rock contact. This approach has not been tested but it may be less effective than piping because it only addresses the issues of contact between flowing mine water and underlying rock, whereas piping should isolate mine water from the surrounding mine workings, as well as the underlying rock. In addition, sediment could likely accumulate in the lined channel over time and defeat the purpose of the lining. For these reasons, channel lining is not considered for evaluation as a potential water quality control measure for Casteel Mine.

3.1.3 Work Area Isolation

As described in the Master Underground Water Management Plan, work area isolation includes “isolating or compartmentalizing those areas to prevent the migration of materials into the water conveyance system.” The master plan suggests work areas may be separated from the remainder of the mine by physical measures such as berms, entrance tunnel modifications, or preplanning of new mine area configurations.

The feasibility of these potential measures was discussed with mine personnel. The challenge to implementing these measures is that they will interfere with mining operations. For example, berms placed between drilling or ore loading areas and water drainage channels will interfere with the passage of vehicles. It is impractical to build the berms up and tear them down every time a vehicle or piece of machinery needs to leave the work area. Entrance tunnel modifications and new mine area pre-planning involve designing tunnels so that a high point exists between work areas and the rest of the mine to prevent the drainage of water impacted by mining activities from leaving the work area. This technique is impractical in most cases because the prevention of mine water drainage from work areas will result in flooding of those work areas. For the reasons discussed above, work area isolation is not considered for further evaluation as a possible water quality control measure for Casteel Mine.

3.1.4 Capture of Drill Fines

The Master Underground Water Management Plan also identified the capture of drill fines as a potential control measure. As stated in the Master Underground Water

Management Plan, drilling is conducted for both mine development and ore recovery operations and the drilling process produces fines which have the potential to become suspended in mine water. Three types of drilling are used at Casteel Mine:

- Jackhammer drilling is a percussion drilling method used for exploratory drilling in the mine. This is a “wet” drilling technique that generates fine material from the borehole that is carried away from the borehole by water.
- Core drilling is a second exploratory drilling technique that uses water to flush fines away from the core barrel and bit to extract a rock core from the borehole. Drill fines are generated during drilling and carried from the borehole by water.
- Production drilling is a percussion drilling method used during mining operations that can be either air mist or water cooled. Fines are generated in the borehole and carried out of the borehole by water or air.

In general, the quantity of fine materials generated during drilling is relatively small and the water generated during wet drilling is very small relative to other sources of flow in the mine. It is generally infeasible to capture drill fines from any of the above techniques because any method used to capture these fines would substantially interfere with drilling operations. For these reasons, capture of drill fines is not considered for further evaluation as a possible water quality control measure for Casteel Mine.

3.2 TREATMENT MEASURES

One type of underground water control measure considered for improving mine water quality is to actually treat the mine water below ground. Treatment processes that may have the potential to improve the quality of mine water include clarification (settling) and filtration.

3.2.1 Clarification

Clarification is a treatment process that involves the removal of suspended solids from water by gravity settling. Simple clarification typically involves the use of basins or sumps that reduce the velocity of flowing water, which allows a portion of suspended solids to settle. Enhanced clarification usually involves the addition of chemicals to facilitate coagulation and flocculation of fine particles that will not settle on their own. These processes are described below:

- Coagulation is the process of adding chemicals to neutralize particle charges that keep particles dispersed. Once the charges of fine particles are neutralized, they will bind together more readily, forming larger particles. This process is often used when very fine particles are suspended.
- Flocculation is the process of providing suitable conditions for fine particles to bind together and often involves very gentle mixing.

Simple clarification is practiced in the Casteel Mine, in the form of mine water sumps. These sumps are located throughout the mine and act as settling basins.

Simple clarification in the form of mine water sumps will be part of the overall mine water management plan for Casteel Mine.

Enhanced clarification using chemicals for coagulation/flocculation, on the other hand, can be a complex process, requiring careful monitoring, with addition of chemicals to adjust the pH of the water being treated for optimization of treatment, followed by readjustment of pH. The process of enhanced clarification results in residuals that are much more difficult to handle and dewater than simple clarification. Providing suitable conditions for settling of the flocculated solids typically requires specialized clarifiers. The challenges of this more complex form of water treatment underground are discussed in Section 3.2.3.

3.2.2 Filtration

Filtration refers to the process of physically separating suspended solids from water by passing the water through material that has openings finer than the suspended materials. This can be accomplished using granular filter materials (e.g., sand filters), woven fabrics, or fabricated plastic or metals filters. The advantage of filtration over clarification is that it results in a more complete separation of water and solids, with the residual solids having lower water content than the residuals of clarification.

Filtration of mine water can potentially be accomplished underground in two ways. First, filters can be used between water sources and water conveyances to remove suspended solids nearer the source. Second, filtration could be used as a centralized treatment process, immediately prior to pumping of mine water to the surface. The use of filtration between water sources and conveyance systems may have potential underground and may be part of the underground water management plan at Casteel Mine. Examples of this are the use of sand berms between flowing coreholes and water collection areas, and filter fabric wrapped around perforated HDPE drainage piping along roadways. Centralized filtration of mine water faces similar challenges as other centralized water treatment processes underground, which are discussed in the following section.

3.2.3 Overall Assessment of Underground Mine Water Treatment Feasibility

Mine water treatment processes, such as filtration between water sources, may be feasible treatment practices for mine water underground. Still, further evaluation is needed to determine the impact of these practices on mine water quality and whether or not they are cost effective. Clarification by means of centralized mine water sumps is currently used at Casteel Mine and will continue to be a part of the overall water management plan. However, other forms of centralized (i.e., large-scale) underground mine water treatment present several challenges, including:

- Available space – Centralized treatment will require a substantial amount of space in the mine. While space is often readily available at the surface, it must be created in the mine by excavating rock. Areas where mining has already occurred are not good candidates because of the possibility that Doe Run may want to return in the future and extract pillars. New areas are expensive to

create; the estimated cost of excavating rock underground is $0.60 per cubic foot (c.f.). In order to build only a sump, approximately a half million cubic feet of rock would need to be excavated, and that only includes the space needed to contain the water. In addition, because the same equipment and personnel would be used to excavate the area for treatment as would be used for mining, there is a cost in lost ore production.

- Protection of treatment processes – It would be difficult to prevent treatment processes from being exposed to airborne dust in the mine, which could cause additional metals loading to the treatment system or otherwise upset the processes.
- Specialized operators – The types of treatment that would be required to reduce metals in mine water, aside from simple settling, would likely require trained operators. Such personnel are not currently deployed underground by Doe Run and their deployment underground would be more costly than above ground.
- Management of residuals – One of the biggest challenges for underground mine water treatment is the management of residuals. Although settled materials can be managed using conventional construction equipment, materials settled by flocculation have higher water content and would likely require specialized equipment. In addition, because they are flowable, they would require larger areas for disposal (i.e., they cannot be piled).

The use of mine water sumps for clarification (both distributed throughout the mine and at centralized locations prior to pumping to surface) will both be part of the underground water management plan for Casteel Mine. Other types of centralized underground mine water treatment do not appear to be feasible at Casteel Mine because of the challenges outlined above and will not be evaluated further.

3.3 GROUNDWATER INTERCEPTION

Groundwater interception is used here to include all measures that prevent water from entering the mine. Water can enter mine areas in a few ways:

- Coreholes – This refers to exploratory borings advanced from the surface to mine depth or from within the mine into the mine face, used to identify ore locations and direct mining activities. Coreholes sometimes intercept fractures and voids in the rock that convey water and then act as drains to allow water from the rock to enter the mine. To date, this has not been a significant source of water entering Casteel Mine.
- Access and vent shafts – These are large-diameter shafts constructed from the surface to mine depth to allow access by personnel and equipment, removal of ore, and ventilation of mine areas. Because they intercept overlying aquifers and penetrate aquitards between the overlying aquifers and the mine, they can become major water sources to the mine. Casing is usually installed in these shafts, which greatly reduces flows. Flows into these shafts can also come

from storm water at the surface, although this contribution is relatively small compared to other flows.

- Fractures – Rock fractures are naturally occurring and mining activities at Casteel occur in an aquifer to begin with, so it is common for those mining activities to intersect water-bearing fractures. When this occurs, the fractures become a means of water entry into the mine.

The primary methods available to intercept groundwater before it enters the mine are sealing of coreholes and fractures, casing of shafts, and aquifer dewatering to prevent groundwater from entering coreholes, shafts, and fractures.

3.3.1 Corehole and Fracture Sealing

When mining operations intersect coreholes and fractures, they can become a source of water to the mine. This can be true for a surface corehole if the corehole was incompletely sealed after drilling or if the seal has somehow failed over time. The Doe Run standard operating procedure for exploratory coreholes requires that coreholes penetrating the Davis shale must be fitted with an expandable packer within the bottom part of the formation and the hole must be filled with grout to at least 50 feet above the top of the Davis formation. This standard operating procedure remains in effect.

If a leaking corehole is encountered during mining operations, the corehole can sometimes be sealed using mechanical packers or grout. Mechanical packers have historically been used and have been shown to be effective, although in some cases stopping the flow from a corehole has caused the flow to enter the mine elsewhere. Casteel Mine personnel may plug coreholes that yield significant flow when they are encountered during mining, however, this has not been necessary in recent years because most coreholes encountered at the Casteel Mine do not have significant flows. In general, mostly at other mines, Doe Run has been evaluating the use of chemical grouts. Two types of chemical grout have been tested at the Fletcher Mine with limited results:

- Two-part grout: This is a two-component grout sold under the trade name H2OSTOP and it has been used for high-inflow coreholes. The grout reacts and sets within seconds of mixing, which is accomplished during injection by a static mixer inside a packer that is inserted in the corehole. The grout can expand in volume up to 20:1 and costs about $195 per cubic foot.

- Moisture-reactive grout: This is a single component grout sold under the trade name Hyperflex that sets in contact with water and is used for lower flow applications. This grout can also expand in volume up to 20:1 and costs about $397 per cubic foot.

These grouts can be effective for sealing fractures as well. Vendor information for both of these products is included in Appendix B. There is no reliable way to estimate how much material will be required to grout a corehole. In the last year, an estimated 200 cubic feet of product has been used. Corehole and fracture sealing will be a part of the underground water management plan for Casteel Mine, where it is feasible, technically possible, and cost-effective to do so. However, at this time there is not a significant need for this activity because, as stated above, most coreholes encountered at the Casteel Mine do not have significant flows.

3.3.2 Shaft Sealing/Repair

Because access and ventilation shafts are necessary for the safe and productive operation of the mine, they cannot be eliminated. Although it is not possible to completely seal the shaft to prevent any water from entering the shaft (and therefore the mine), the standard practices employed by Doe Run are usually capable of eliminating most of the flow. These practices involve the installation of casings in the shafts to seal out water. At present, the shafts at Casteel Mine are not a major source of mine water flow. Therefore, shaft sealing/repair is not considered for further evaluation as a possible water quality control measure for Casteel Mine.

3.3.3 Aquifer Dewatering

The only other potential flow reduction measure to prevent water from entering the mine is interception of the groundwater in the aquifer before it reaches the mine. This would require installation of dewatering wells at critical points around the mine, at the depth of the contributing aquifers, and pumping of groundwater from the wells. Implementation of aquifer dewatering is a substantial and costly undertaking that would typically only be evaluated for very large sources of flow. Aquifer dewatering would require the following steps:

- Hydrogeological investigation to fully characterize water-bearing units around and above the mine.
- Installation of pumping wells to test the rates at which water could be pumped from the aquifer and the drawdowns in potentiometric surface that could be achieved.
- Evaluation of the ability of pumped groundwater to meet surface water future final discharge limits.
- Upon completion of the above testing, the dewatering system would be designed and constructed.

One major advantage of this approach is that it involves pumping of groundwater to the surface before it comes into contact with the mine workings. This would presumably eliminate the need for treatment at the surface prior to discharge. It is likely not feasible, however, to use aquifer dewatering for an entire mine, miles in length, due to the costs involved, therefore, aquifer dewatering is not considered for further evaluation as a possible water quality control measure for Casteel Mine.

3.4 BEST MANAGEMENT PRACTICES

There are several underground water management practices that can potentially be used to maintain or improve mine water quality. These are referred to as best management practices (BMPs) and several were identified in the Master Underground Water Management plan, including the following:

- Berms
- Channels
- Collection and Containment of Impacted Water
- Clean Mining Areas
- Material Handling and Storage
- Erosion Control
- Roadway Maintenance
- Maintenance Schedules

In addition, sump cleaning and inspections were identified as BMPs that should be considered. These BMPs are discussed below.

3.4.1 Berms

The use of berms was discussed previously in this plan (Section 3.1.3). Because even temporary berms will interfere with the movement of vehicles and equipment in the mine, where working space is already limited, it does not appear that their use is feasible, except in situations where flows can be directed to inactive mining areas, which is already done at Casteel Mine.

3.4.2 Channels

Shallow channels are already used throughout Casteel Mine to convey mine water flows. As discussed in Section 3.1.2, these channels are already problematic because they expose mine water to more impacts from mine workings. The potential for replacing open channels with enclosed pipes will be discussed in Section 4.

3.4.3 Collection and Containment of Impacted Water

Once water is impacted by exposure to mine workings, it should be isolated from unimpacted water. For example, if impacted water is created at the working mine face during ore extraction operations, it should not be mixed with unimpacted water seeping from coreholes, if this can be avoided.

3.4.4 Clean Mining Areas

In general, maintaining clean mining areas may help reduce the potential for mining activities to impact mine water. This “good housekeeping” practice will be employed to the extent possible in all mining areas and may include storage of ore, drill fines, waste rock, and mining equipment away from areas where water is collected.

3.4.5 Material Handling and Storage

This BMP refers to practices for handling and storage of materials that have the potential to impact mine water quality. This may include stockpiled ore or it may include solids removed from sumps during mucking. The practice for storing such material stockpiles will be that they are placed so as to minimize impacts to mine water.

3.4.6 Erosion Control

As described in the Master Underground Water Management Plan, erosion control in mines includes the protection of any surface that has the potential to erode and increase the loading of suspended solids. These areas include material storage piles and transportation corridors. At Casteel Mine, erosion control of storage piles will be addressed by material handling and storage practices and erosion control of transportation corridors will be addressed to the extent feasible by the roadway maintenance program.

3.4.7 Roadway Maintenance

The heavy traffic of trucks and mining equipment over mine roadways, which are normally constructed of crushed rock, can result in erosion of the road surface. This can have two related impacts on mine water quality. First, the erosion of road materials can move fine materials into roadside channels filled with water. Second, the erosion can result in a lowering of the road bed over time, which can eventually lead to flooding of the eroded part of the road. Regular inspection of roadways and prompt repair of eroded areas will be part of the underground water management plan for Casteel Mine.

3.4.8 Maintenance Schedules

Scheduling of maintenance activities related to underground water management at Casteel Mine will be driven by monitoring and inspection activities, as discussed in Section 4.

3.4.9 Sump Cleaning

At Casteel Mine, like all Doe Run mines, mine water flows via gravity and/or pumping to central sumps where it is then pumped to the surface. At Casteel Mine, three main mine water sumps are currently used.

All mine water sumps provide temporary storage for mine water and, as a result, can have potential for settling solids, proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids, by design. This means, however, that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, accumulated solids could eventually impair pumping. For these reasons, periodic maintenance of the sumps is required to remove solids. The process of sump cleaning is referred to as “sump mucking”.

Sump mucking involves temporarily draining the sump, then mechanically removing the accumulated solids from the sump. The solids are transported to an inactive area of the mine for storage, where they dewater by gravity drainage. Since they consist of fine rock and ore, the dewatered solids are sometimes added to the mined materials sent to the surface for processing.

Experience at Doe Run mines shows that sump cleaning results in excessive wear on the machinery that is used to remove the accumulated solids because the fine solids get into the mechanical and hydraulic components of the machinery and are abrasive. Significant costs can be incurred for equipment refurbishment after every sump mucking event. Because sump cleaning is a necessary component of mine operations, it will be continued in the future and is discussed further in Section 4.

3.4.10 Inspections

Regular inspection of mine water management measures will be an important part of the overall underground water management plan at Casteel Mine. These inspections will be used to monitor effectiveness of the plan and to identify the need for maintenance of roadways, piping, sumps, and other mine water management measures.

3.5 SUMMARY OF WATER MANAGEMENT MEASURE EVALUATION

Several potential water management measures have been identified for the Casteel Mine as they may have the potential to reduce mine water flows and improve water quality. The measures are summarized in Table 3-1 along with notation on which will be part of the Casteel underground water management plan. In all cases, the use of the measures discussed here will be evaluated and implemented if Doe Run determines that the measures are effective, technically feasible, and cost effective, or will be further evaluated for potential implementation.

Table 3-1. Summary of Water Management Measure Evaluation for the Casteel Mine.

Type of Measure	Measure	Assessment Summary	Included in Casteel UGWMP?
Isolation	Piping	Potentially effective on a localized basis; to be evaluated further	Yes
	Channel lining	Not an effective control measure	No
	Work area isolation	Not feasible	No
	Capture of drill fines	Not feasible	No
Treatment	Clarification	Simple settling feasible; enhanced clarification infeasible	Yes
	Filtration	Potentially feasible on a localized basis; will undergo further evaluation	No
Groundwater Interception	Corehole/fracture sealing	Not currently needed; will be considered on an as-needed basis in the future	No
	Shaft repair/sealing	Not needed	No
	Aquifer dewatering	Not part of plan, pending outcome of investigations at Sweetwater Mine	No
Best management practices (all to undergo regular review and evaluation)	Berms	Useful in some case	Yes
	Channels	Necessary, piping preferred in some areas	Yes
	Collection/ containment	Potentially useful	Yes
	Clean mining areas	Potentially useful	Yes
	Material handling/storage	Potentially useful	Yes
	Erosion control	Addressed by material handling & roadway maintenance	No
	Roadway maintenance	Potentially useful	Yes
	Maintenance schedules	Necessary, driven by monitoring and inspections	Yes
	Sump cleaning	Necessary	Yes
	Inspections	Necessary	Yes

This page is blank to facilitate double sided printing.

4. PLAN ELEMENTS AND IMPLEMENTATION

The underground water management plan for Casteel Mine is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of potential measures focusing on cost-effectiveness and impact on water quality;
- Development of planned actions;
- Implementation of planned actions;
- Monitoring of implemented actions (data collection and inspection);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Casteel Mine plan discussed in this section are:

- Water management actions
- Best management practices
- Monitoring
- Inspection
- Recordkeeping
- Training
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections. It should be noted that mine water treatment evaluations are ongoing at Doe Run. The outcome of these evaluations will determine the most effective mine water treatment method, as well as an accurate estimate of the unit cost for mine water treatment. This will allow evaluation of potential underground water control measures in the context of relative cost-effectiveness, compared to treatment at the surface. Based on these comparisons, some of the measures discussed in this section may be determined not to be cost effective and may be removed from the plan in the future.

4.1 WATER MANAGEMENT ACTIONS

Based on the review of mine data discussed in Section 2 and the evaluation of potential control measures discussed in Section 3, existing practices and procedures, as well as planned projects, are generally sufficient for underground water management at Casteel Mine. In addition, two contingency plans will be set up for the Casteel Mine to address future potential opportunities for water management actions: corehole sealing contingency and piping contingency. These are described below.

4.1.1 V10 Mine Water Sump

As discussed in Section 2.1.1 of this plan, construction of a new mine water sump in the north part of Casteel Mine was completed in February 2012. This sump, called the V10 sump, increased the mine water pumping capacity at Casteel by 3,000 gpm. Because most of the mine water in Casteel comes from the north mine, the location of the V10 sump will reduce mine water travel time, thereby reducing the potential for exposure to mine workings. In addition, new piping will be installed to direct flows to the sump, which will further reduce the exposure of the water to the workings. The overall effect of this project on mine water quality is still yet unknown, but will be monitored.

4.1.2 Corehole Sealing Contingency Program

Although coreholes are not currently a significant source of influent mine water at Casteel Mine, there is the possibility that coreholes may be encountered in the future that yield higher flows. For this reason, a corehole sealing contingency program will be implemented. This contingency program will include a standard operating procedure and decision framework for determining which coreholes will be sealed. This plan formalizes the framework for determining which coreholes will be sealed. New coreholes that are encountered during mining operations and that produce significant flows to the mine may be sealed, if sealing is technically possible and cost-effective. If possible, the following procedure will be followed:

- Flowrate from the corehole will be estimated by measuring the time required to fill a 55-gallon drum or other similarly-sized container of known volume. If it is not possible to measure the flowrate from the corehole in this manner due to the location of the corehole and difficulty in positioning the container under the stream of flow, a 5-gallon bucket or similar smaller container shall be used. If this is also impractical due to the very small quantity of flow or for safety reasons, the underground water management team will discuss alternate flow estimation methods. Because flows from newly encountered coreholes sometimes vary, the flow will be measured once a month for three months.
- The diameter of the corehole will be measured to the nearest inch. If it is impossible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.
- After measuring the flow and the corehole diameter, the underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past. If the underground water management team is not certain whether sealing is feasible, they will consult with manufacturer’s representatives for mechanical plugs and grouts to help determine the feasibility of sealing the corehole.

- If it is determined that the corehole can be sealed, the underground water management team will determine a schedule for sealing that takes into account the priority of the action relative to other water management measures.

The above process is documented in the form of a standard operating procedure, included in Appendix C. Corehole sealing will be documented in writing. The methods and procedures used for sealing will be documented, along with problems encountered and apparent success of the sealing, for future reference.

4.1.3 Piping Contingency Program

No piping projects are currently planned for the Casteel Mine for the sole purpose of addressing water quality. However, future circumstances may warrant consideration of piping to address water quality, so a contingency program for piping will be maintained as part of this plan.

Data collected at Doe Run mines indicate that the quality of mine water entering mines can be degraded within a short distance of the point of entry. Therefore, before piping to maintain water quality, the underground water management team will continue to determine whether the piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation. This will likely be accomplished by containing the water at the point of entry with a sump or other system and piping directly from the sump to a main mine water sump.

If the source of the incoming water is a corehole, the procedures outlined in Section 4.1.2 will be followed before piping is evaluated. If the source of the water is a corehole that cannot be sealed, the underground water management team will use the following protocol to determine whether piping will be installed:

- The physical setting and surroundings of the source will be assessed by the underground water management team to identify options for containing the incoming flow as close to its source as possible. This process will consider quantity of flow, space availability, accessibility of the source, other mine operations, cost, and safety.
- Once the most feasible and cost-effective option for containing the flow is determined, the underground water management team will determine the flow path the water will follow to reach the containment area. Water samples will then be collected at the end of that flow path, at the point where water would enter the containment area, as well as the point of entry to the mine (i.e., the corehole, fracture, or shaft). This water sampling will follow the standard procedures for sampling that are currently in place for water sample collection.
- The sampling results will be compared to the results for the incoming water as a measure of the water quality degradation that will occur along the flow path to the location of the containment. The results will also be compared to water quality data from the mine water sump to which the water would be

piped. The underground water management team will use these comparisons to determine whether the piping is likely to provide a significant water quality benefit and whether the piping is cost-effective.

All data collected during piping evaluations will be recorded. Upon review of new data in the future, if a piping project is determined to be ineffective, the piping project may be terminated or, if already installed, the piping may be removed for use elsewhere.

4.1.4 Ongoing Water Management Measure Evaluations

In addition to the corehole sealing and piping contingency programs described above, the following additional actions will be considered on an as-needed basis:

- Additional piping – As mine expansion occurs, significant inflows of relatively clean groundwater may be encountered and, in some cases, it may be feasible and cost-effective to contain the water locally and pipe it directly to mine water sumps. This measure will be evaluated by the water management team on a case-by-case basis.
- New corehole sealing techniques/materials – The water management team will continue to evaluate new techniques or materials for corehole sealing, as they become available.
- New mine water pump shafts – As mining operations progress, it may become feasible to construct new pump shafts to the surface, as an alternative to moving water from newly mined areas to existing mine water sumps. This will be evaluated by the water management team on an as-needed basis.
- Mine expansion – During mine expansion activities, mine personnel will consider water management strategies from a water quality, as well as logistical, perspective and identify environmentally-appropriate water management strategies into the expansion design.

As with the planned activities described in the preceding section, control measure evaluations will be documented in future updates to this plan.

In addition to the contingency actions outlined above, best management practices, as described in Section 4.2, will be used to manage water quality.

4.2 BEST MANAGEMENT PRACTICES

Several BMPs will be implemented at Casteel Mine as part of this plan, as described in the following sections. Some of these BMPs, such as berms, channels, collection, and clean mining areas will likely be used relatively infrequently because of their limited applicability. Others, such as roadway maintenance and sump cleaning will be performed more frequently, but still on an as-needed basis. BMPs and the conditions where they may be useful will be discussed during personnel training.

4.2.1 Berms

Berms are low barriers used to direct flowing water in a desired direction, away from its natural course. Although the use of berms to contain water within work areas is infeasible due to interference with mining activities, as described in Section 3.1.3, berms may be useful in areas of the mine where active mining and hauling is not occurring. Berms may be considered a potential water management practice in areas where they will not interfere with mining.

4.2.2 Channels

Channels are shallow watercourses, usually along roadways, in the mine. Although allowing water to flow uncovered in channels has been identified as a source of water quality degradation, there may be situations where construction of channels will be useful. For example, as with berms described above, channels may be useful in diverting flow away from main mine water sumps towards unused or inactive areas of the mine. In such situations, a simple open channel might be used or a combination of channel and pipe may be used, where the diverted flow has to cross a roadway.

4.2.3 Collection/Containment

Collection or containment may be used, where feasible and cost-effective, in situations where water impacted by mining activities is in proximity to sources of relatively unimpacted water. Possible collection/containment techniques may include:

- Construction of a local sump to collect the impacted mine water or the unimpacted water source for pumping.
- Use of diversion channels or berms to direct the flow of impacted mine water away from the source of unimpacted water.

The appropriate method of collection or containment will be determined on a case-by-case basis. In situations where the unimpacted water source is a newly discovered corehole, the procedure for evaluating corehole sealing will be followed.

4.2.4 Clean Mining Areas/Material Handling and Storage

The ‘Clean Mining Areas’ and ‘Material Handling and Storage’ BMPs discussed in Sections 3.4.4 and 3.4.5 are combined here because they are closely related. This combined BMP refers to maintaining work areas in the vicinity of open mine water in such a way as to minimize the potential for water quality degradation. This is especially relevant to areas around sumps and around channels that have not been piped. Where possible, stockpiled materials such as ore and waste rock should be located to minimize impacts to water. Equipment should also be stored away from water where possible.

4.2.5 Roadway Maintenance

Roadways will be inspected on a regular basis by mine supervision personnel and any significant repairs will be documented. These inspections will be specifically directed at identifying roadway conditions that might contribute to water quality degradation including, but not necessarily limited to, the following:

- eroded sections of the roadway that are likely to contribute to the degradation of mine water quality (repaired by filling to an acceptable grade)
- broken or plugged drain pipes (repaired by replacing broken pipe or clearing plug)
- water entering from the back and falling onto the road causing erosion (repaired by suspended curtains of suitable material over the roadway to divert falling water to ditches)

It should be noted that there may be cases where a low point in a roadway exists because it is the low point of the mine tunnel and not necessarily due to erosion. In such cases, filling may create insufficient clearance between passing trucks and the back, so repair is not feasible. When appropriate, significant problems and repairs will be logged in the Doe Run Enterprise Task Management System (ETMS).

4.2.6 Maintenance Schedules

Maintenance related to underground water management at Casteel Mine will be performed on an as-needed basis. Regularly scheduled inspections may identify additional maintenance needs.

4.2.7 Sump Cleaning

The main mine water sump will be inspected quarterly as part of the routine water management inspection program at Casteel Mine. Part of this inspection will be reading of depth soundings to monitor the level of accumulated solids in the sump. If it is logistically possible, the main mine water sump at Casteel Mine will be equipped with a sonar depth finder capable of measuring the depth to the sediment/water interface. If this equipment can be installed, initially, a decrease in water depth of 50% at a point in close proximity to the pumps will be used to trigger sump cleanout. This level of fill is based on the experience of mine personnel. As described below, the main mine water sump will be sampled on a regular basis and these data will be evaluated along with the level of accumulated sediment to determine whether a different level should be used to trigger sump cleaning. A standard operating procedure for monitoring sediment levels in main mine water sumps is included in Appendix C.

4.3 MONITORING

Ongoing underground water quality monitoring will be continued at the Casteel Mine to improve the understanding of mine water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 4-1 will be sampled, unless it is determined by Doe Run that an adequate amount of data has been collected.

Table 4-1. Underground Water Sampling Locations for the Casteel Mine.

Location	**Sample ID Previously Used**	**Rationale**
Lower Main mine water sump influent	CS-LWMNSUMP	Water quality entering sump
Lower Main mine water sump near pumps	CS-LWMNSUMPNP	Water quality leaving sump
Upper Main mine water sump influent	CS-UPMNSUMP	Water quality entering sump
Upper Main mine water sump near pumps	CS-UPMNSUMPNP	Water quality leaving sump
V10 sump influent	CS-V10SUMPINF	Water quality entering sump
V10 sump near pumps	CS-V10SUMPNP	Water quality leaving sump
CDH62	CS-CDH62	Mine water quality entering North mine
CDH53	CS-CDH53	Mine water quality entering West mine
CDH54	CS-CDH54	Mine water quality entering South mine
86 Sump influent	CS-86 Sump INF	Mine water quality in 86 sump

Continued monitoring was initiated in January 2012, and has typically been conducted on a monthly basis. The results of the continued monitoring efforts are presented in Figures 4-1 through 4-5. Evaluation of the most recent data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

In addition to the monitoring regime described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for underground water management at Casteel Mine.

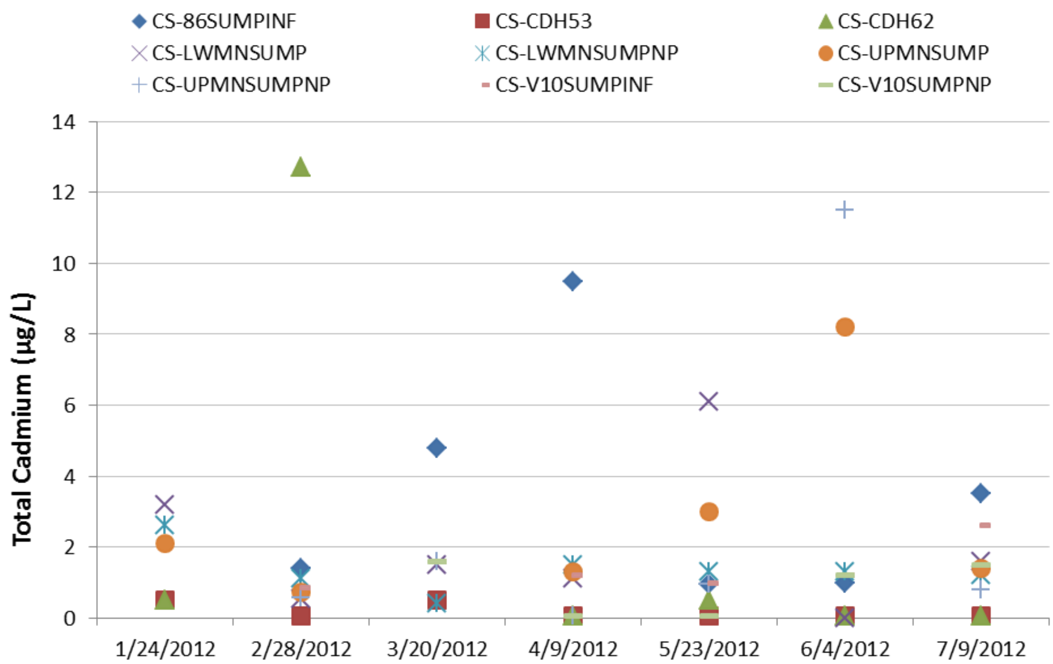


Figure 4-1. Continued Monitoring of Total Cadmium in Underground Sampling Locations at Casteel Mine.

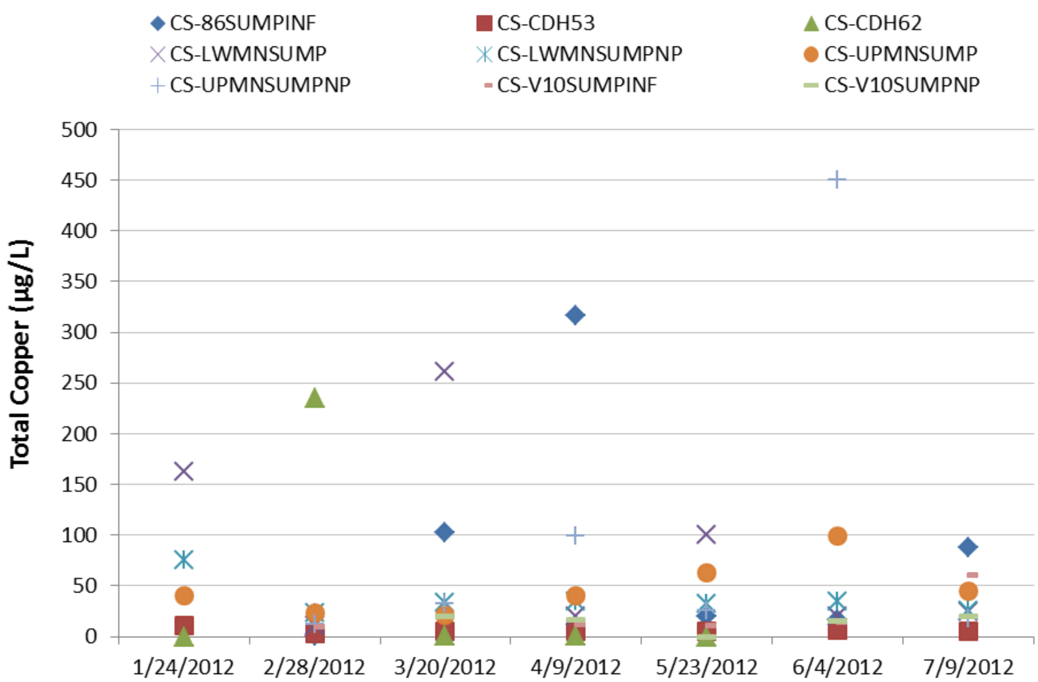


Figure 4-2. Continued Monitoring of Total Copper in Underground Sampling Locations at Casteel Mine.

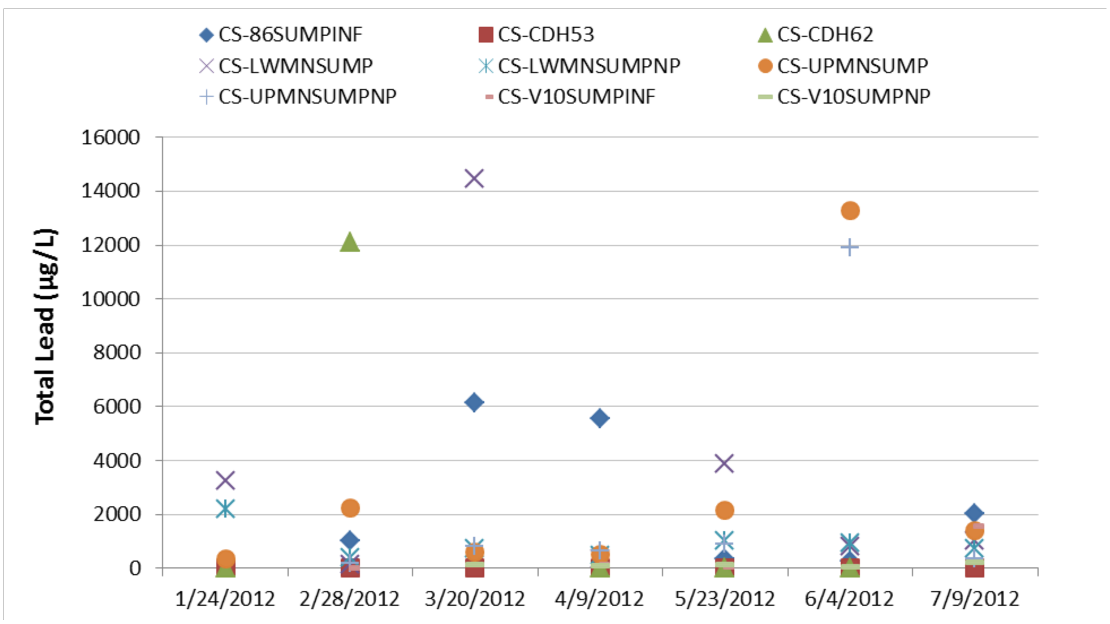


Figure 4-3. Continued Monitoring of Total Lead in Underground Sampling Locations at Casteel Mine.

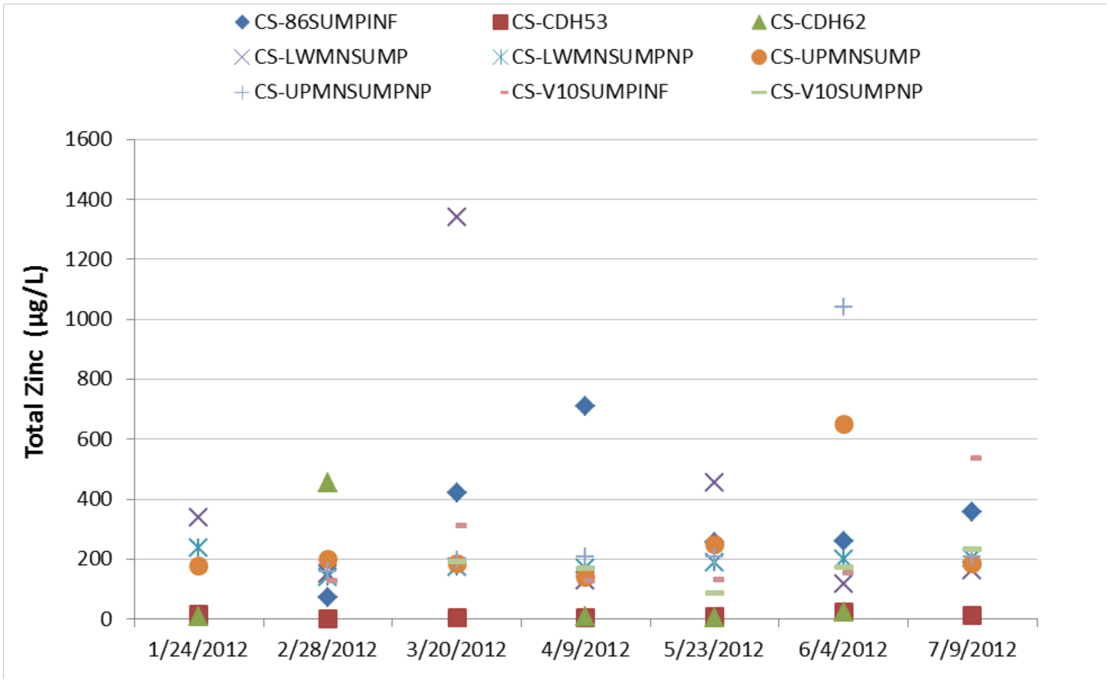


Figure 4-4. Continued Monitoring of Total Zinc in Underground Sampling Locations at Casteel Mine.

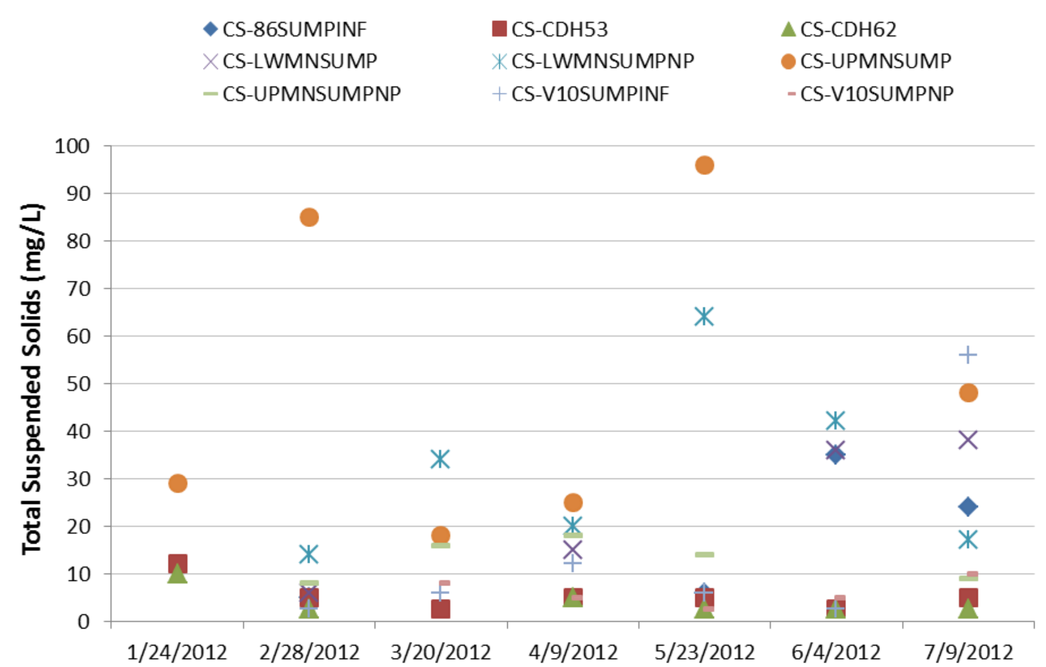


Figure 4-5. Continued Monitoring of Total Suspended Solids in Underground Sampling Locations at Casteel Mine.

4.4 INSPECTIONS

Underground water management inspections will be conducted at Casteel Mine on a quarterly basis to monitor effectiveness of water management measures and to identify the need for maintenance. Inspections will include visual inspection of the following:

- Main mine water sump to visually assess turbidity and general condition;
- Water piping, to identify leaks;
- Roadways, to identify the need for maintenance;
- Material and equipment storage areas to identify the need for improved separation from sources, conveyances, and sumps;
- Coreholes and/or fractures scheduled for sealing between the previous and current inspections, if any, to verify that sealing has occurred and was effective;
- Sources of water identified since the previous inspection; and
- Any other water management actions undertaken since the last inspection.

Inspections will be conducted by trained personnel (see Section 4.5). All inspections will be documented using the form in Appendix D, which will include the name and signature of the person performing the inspection.

4.5 TRAINING

Training was identified in the Master Underground Water Management Plan and will be an important part of the plan for Casteel Mine. Initial training will be provided by March 31, 2012 to all personnel involved in the management of water at Casteel Mine including, but not necessarily limited to:

- Mine supervision
- Mine engineers
- Technical service personnel
- Environmental technicians

In addition to the initial training for these personnel, annual refresher training will be conducted.

The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for underground water management (including the environmental need);
- Best management practices to be used throughout the mine;
- Specific water management actions being implemented or planned;

- Water management protocols and standard operating procedures;
- Inspections;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

4.6 TRACKING/RECORD-KEEPING

Water management measures will be inspected at Casteel Mine quarterly and the inspections will be documented on the form included in Appendix D. These forms will be kept on file on-site by the Casteel Underground Water Manager, Randy Arndt or designee. In addition, all significant water management measures and best management practices implemented at Casteel Mine will be documented in writing and a copy kept on file at the same location. Actions taken, best management practices, inspections, and maintenance of underground water management measures will be recorded in the Doe Run ETMS.

4.7 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between November 1 and December 31, 2012. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Casteel Mine facility.

4.8 IMPLEMENTATION SCHEDULE

The current schedule for the water management plan implementation is presented in Table 4-2. This schedule is based on the best information available as of the date of this plan.

Table 4-2. Current Implementation Schedule for Underground Water Management Plan Activities at Casteel Mine.

Action	Jan. 2012	Feb. 2012	Mar. 2012	April 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Mar. 2013	Nov. 2013	Dec. 2013
Training															
Inspections	Once per Calendar Quarter														
Sampling											As needed				
V10 Sump Completion															
Plan Review & Update															

5. REFERENCES

LimnoTech. Underground Water Sampling and Analysis Plan Report. August 4, 2011. (LimnoTech, 2011)

Resource Environmental Management Consultants, Inc. *Master Underground Water Management Plan: The Doe Run Company SEMO Operations*. 2010. (RMC, 2010)

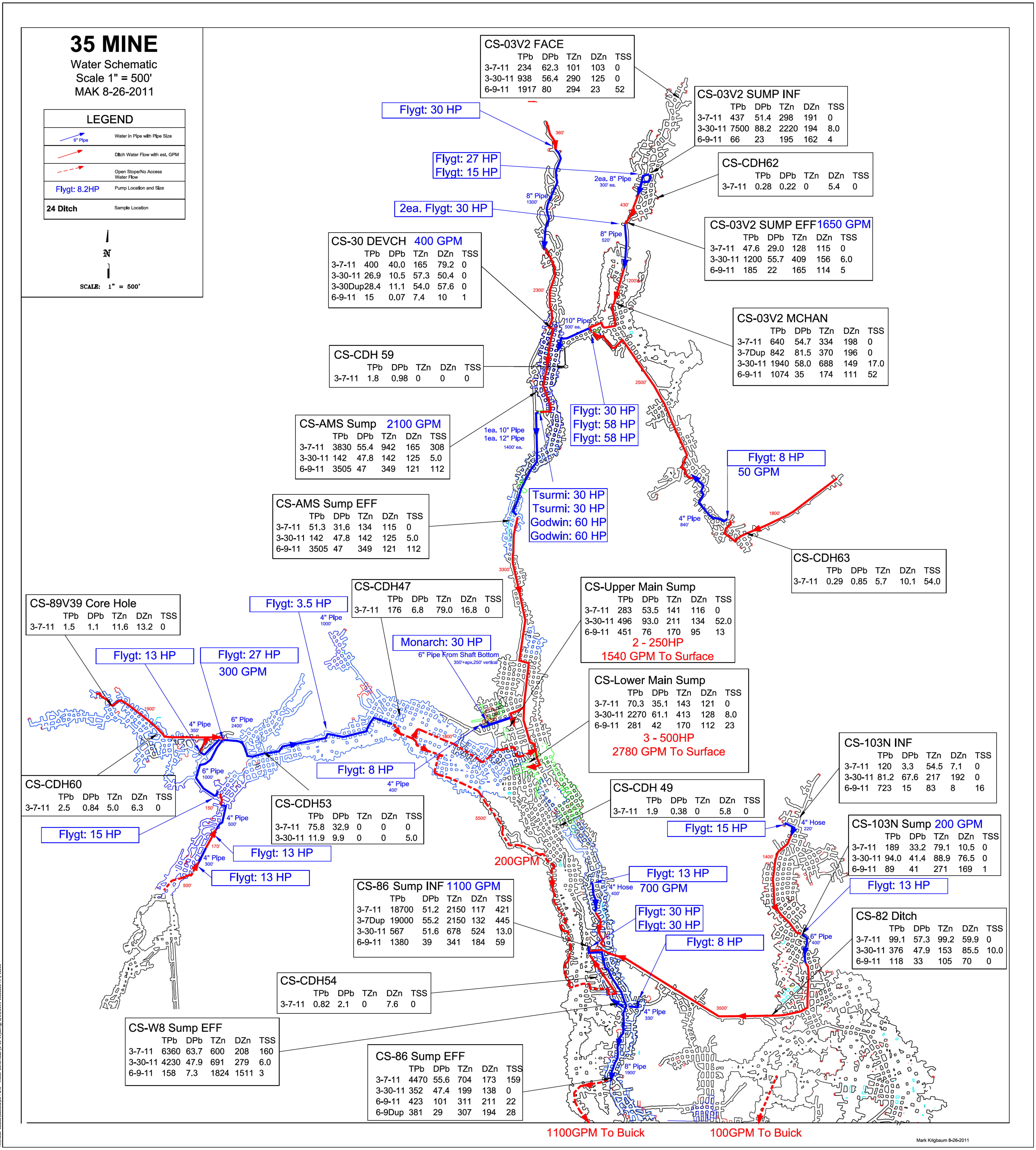
U.S. Geological Survey. "History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict" (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008)

This page is blank to facilitate double sided printing.

APPENDIX A:

CASTEEL MINE WATER FLOW MAP WITH LEAD AND ZINC SAMPLING RESULTS

This page is blank to facilitate double sided printing.


35 MINE
Water Schematic
Scale 1" = 500'
MAK 8-26-2011
LEGEND
6" Pipe
Water in Pipe with Pipe Size
Ditch Water Flow with est. GPM
Open Stope/No Access Water Flow
Flygt: 8.2HP
Pump Location and Size
24 Ditch
Sample Location
N
SCALE: 1" = 500'
CS-03V2 FACE
TPb DPb TZn DZn TSS
3-7-11 234 62.3 101 103 0
3-30-11 938 56.4 290 125 0
6-9-11 1917 80 294 23 52
CS-03V2 SUMP INF
TPb DPb TZn DZn TSS
3-7-11 437 51.4 298 191 0
3-30-11 7500 88.2 2220 194 8.0
6-9-11 66 23 195 162 4
Flygt: 30 HP
Flygt: 27 HP
Flygt: 15 HP
CS-CDH62
TPb DPb TZn DZn TSS
3-7-11 0.28 0.22 0 5.4 0
2ea. 8" Pipe
300' ea.
8" Pipe
1300'
2ea. Flygt: 30 HP
8" Pipe
520'
CS-03V2 SUMP EFF 1650 GPM
TPb DPb TZn DZn TSS
3-7-11 47.6 29.0 128 115 0
3-30-11 1200 55.7 409 156 6.0
6-9-11 185 22 165 114 5
CS-30 DEVCH 400 GPM
TPb DPb TZn DZn TSS
3-7-11 400 40.0 165 79.2 0
3-30-11 26.9 10.5 57.3 50.4 0
3-30Dup 28.4 11.1 54.0 57.6 0
6-9-11 15 0.07 7.4 10 1
CS-03V2 MCHAN
TPb DPb TZn DZn TSS
3-7-11 640 54.7 334 198 0
3-7Dup 842 81.5 370 196 0
3-30-11 1940 58.0 688 149 17.0
6-9-11 1074 35 174 111 52
10" Pipe
500' ea.
CS-CDH 59
TPb DPb TZn DZn TSS
3-7-11 1.8 0.98 0 0 0
CS-AMS Sump 2100 GPM
TPb DPb TZn DZn TSS
3-7-11 3830 55.4 942 165 308
3-30-11 142 47.8 142 125 5.0
6-9-11 3505 47 349 121 112
1ea. 10" Pipe
1ea. 12" Pipe
1400' ea.
Flygt: 30 HP
Flygt: 58 HP
Flygt: 58 HP
Flygt: 8 HP
50 GPM
Tsurmi: 30 HP
Tsurmi: 30 HP
Godwin: 60 HP
Godwin: 60 HP
CS-AMS Sump EFF
TPb DPb TZn DZn TSS
3-7-11 51.3 31.6 134 115 0
3-30-11 142 47.8 142 125 5.0
6-9-11 3505 47 349 121 112
4" Pipe
840'
CS-CDH63
TPb DPb TZn DZn TSS
3-7-11 0.29 0.85 5.7 10.1 54.0
CS-89V39 Core Hole
TPb DPb TZn DZn TSS
3-7-11 1.5 1.1 11.6 13.2 0
Flygt: 3.5 HP
4" Pipe
1000'
CS-CDH47
TPb DPb TZn DZn TSS
3-7-11 176 6.8 79.0 16.8 0
CS-Upper Main Sump
TPb DPb TZn DZn TSS
3-7-11 283 53.5 141 116 0
3-30-11 496 93.0 211 134 52.0
6-9-11 451 76 170 95 13
2 - 250HP
1540 GPM To Surface
Flygt: 13 HP
Flygt: 27 HP
300 GPM
Monarch: 30 HP
6" Pipe From Shaft Bottom
CS-Lower Main Sump
TPb DPb TZn DZn TSS
3-7-11 70.3 35.1 143 121 0
3-30-11 2270 61.1 413 128 8.0
6-9-11 281 42 170 112 23
3 - 500HP
2780 GPM To Surface
4" Pipe
350'
6" Pipe
2400'
6" Pipe
1000'
CS-CDH60
TPb DPb TZn DZn TSS
3-7-11 2.5 0.84 5.0 6.3 0
Flygt: 8 HP
4" Pipe
400'
CS-103N INF
TPb DPb TZn DZn TSS
3-7-11 120 3.3 54.5 7.1 0
3-30-11 81.2 67.6 217 192 0
6-9-11 723 15 83 8 16
CS-CDH 49
TPb DPb TZn DZn TSS
3-7-11 1.9 0.38 0 5.8 0
CS-CDH53
TPb DPb TZn DZn TSS
3-7-11 75.8 32.9 0 0 0
3-30-11 11.9 9.9 0 0 5.0
4" Pipe
500'
Flygt: 15 HP
Flygt: 15 HP
4" Hose
220'
CS-103N Sump 200 GPM
TPb DPb TZn DZn TSS
3-7-11 189 33.2 79.1 10.5 0
3-30-11 94.0 41.4 88.9 76.5 0
6-9-11 89 41 271 169 1
Flygt: 13 HP
4" Pipe
300'
Flygt: 13 HP
200GPM
Flygt: 13 HP
700 GPM
4" Hose
400'
Flygt: 13 HP
CS-86 Sump INF 1100 GPM
TPb DPb TZn DZn TSS
3-7-11 18700 51.2 2150 117 421
3-7Dup 19000 55.2 2150 132 445
3-30-11 567 51.6 678 524 13.0
6-9-11 1380 39 341 184 59
Flygt: 30 HP
Flygt: 30 HP
Flygt: 8 HP
6" Pipe
400'
CS-82 Ditch
TPb DPb TZn DZn TSS
3-7-11 99.1 57.3 99.2 59.9 0
3-30-11 376 47.9 153 85.5 10.0
6-9-11 118 33 105 70 0
CS-CDH54
TPb DPb TZn DZn TSS
3-7-11 0.82 2.1 0 7.6 0
4" Pipe
330'
CS-W8 Sump EFF
TPb DPb TZn DZn TSS
3-7-11 6360 63.7 600 208 160
3-30-11 4230 47.9 691 279 6.0
6-9-11 158 7.3 1824 1511 3
CS-86 Sump EFF
TPb DPb TZn DZn TSS
3-7-11 4470 55.6 704 173 159
3-30-11 352 47.4 199 138 0
6-9-11 423 101 311 211 22
6-9Dup 381 29 307 194 28
8" Pipe
1900'
1100GPM To Buick
100GPM To Buick
Mark Krigbaum 8-26-2011

APPENDIX B:

VENDOR INFORMATION ON GROUT USED FOR COREHOLE SEALING

This page is blank to facilitate double sided printing.

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

STI 03 - 0.03

H20STOP

Dual component, low density, highly reactive, early strength, water control grout

Uses

Water control in mining and civil applications for cessations of high (3,000 G.P.M. +) leaks, combined with rapid void filling and early strength characteristics.

Advantages

- **Extremely fast reacting**
- **Rapid sealing**
- **High early strength**
- **Will inject into the finest of fractures**
- **Will not wash out**

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture. Store under 80 degrees.

Packaging

55 Gallon Steel Drums

Approvals – On file

Transport

USDOT Unregulated Class 55

Shelf Life

2 Year minimum in unopened containers.

Physical Properties

-20º F (shrinkage)	0% 1 day	ASTM D-2126
Viscosity @ 68º F	200 cps A – Side	300 cps B – Side
Specific Gravity @ 60º F	1.23 A - Side	1.04 B - Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Density (Free Rise)	03 PCF	ASTM D-1622
Compressive	200 psi	ASTM D-1621
Tensile	112 psi	ASTM D-638
Shear	107 psi	ASTM D-732

Sub-Technical, Inc.
363 Mars Valencia Road
Mars, Pennsylvania 16046 U.S.A.
Phone: (724)625-0008 Fax: (724)625-0009
www.sub-technical.com
stisales@sub-technical.com

Always Read MSDS Sheets Prior to USE

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

HYPERFLEX

Single component, low density, flexible, hydrophobic grout.

Uses

Sealing of water and gasses in mining and civil applications. Reacts with moisture to form a flexible closed cell grout.

Advantages

- **Simple application**
- **Adjustable set time with catalyst**
- **Flexible, absorbs movement**
- **Low expansive pressure**
- **"Self injection" into the finest of fractures**

Packaging

55 Gallon Steel Drums

5 Gallon Plastic Containers

5 Gallon Metal Containers

1 Gallon Metal Containers

Approvals

NSF 61-2007 approved for use with potable water.

Transport

USDOT. Unregulated Class 55

Physical Properties

Density	Free rise	2.25 lbs/ft³
Low temp. aging	Confirmed	
-20° F (shrinkage)	0% 1 Day	ASTM D-2126
Viscosity	4000 cps	ASTM D-2126
Specific Gravity @ 60° F	1-30%	A-Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Compressive	25 psi	ASTM D-1621
Shear	171 psi	ASTM C-273
Tensile	30 psi	ASTM D-1623
Elongation	300%	ASTM D-1623

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture.

Shelf Life

2 year minimum in unopened containers.

Caution: Always read MSDS prior to use.

WWW.Sub-Technichal.com

724 625 0008 VOICE 724 625 0009 Fax

APPENDIX C:

STANDARD OPERATING PROCEDURES

This page is blank to facilitate double sided printing.

I. INTRODUCTION

Mine water sumps provide temporary storage for mine water, which results in the settling of solids proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids. This means that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, the accumulated solids could eventually impede pumping. For these reasons, periodic maintenance of the sumps is required to remove accumulated solids.

The process of sump cleaning is referred to as "sump mucking". This involves draining the sump, then mechanically removing the accumulated solids from the sump. This standard operating procedure provides guidelines for monitoring main mine water sumps and determining the need for sump cleanout.

II. MATERIALS

The following materials will be available to monitor mine sumps:

- Personal protective equipment as required by the Health and Safety Plan;
- Light source;
- Depth finding device;
- Tape measure;
- Field log;

III. PROCEDURES / GUIDELINES

All major mine sumps will be cleaned when the accumulated solids exceed 50% of the water depth in the sump at the point of measurement near the pumps. To determine the sump mucking trigger, the following procedures must be adhered to:

A. Depth Measurement

1) A depth finding sonar device will be installed near the pumps at each of the major mine sumps to measure the depth of sediment in the sump.
2) A standard reference mark will be established for each sump, to which the water level can be referenced on a recurring basis.
3) The water level will be determined by measuring from the standard reference mark down to the water level with a tape measure.
4) As an alternative to steps 2 and 3, mine personnel may opt to install a staff gauge in the sump for measuring water level.

B. Inspection

1) During each quarterly inspection, the water level and depth to solids in each sump will be recorded from depth finding device.

C. Documentation

The following information will be recorded:

1) Sump identification/location
2) Sump inspection date
3) Measurement of water level
4) Measurement of depth to sediment in each sump
5) Notification of underground water management team, if the depth of solids is more than 50% of the water depth in the sump
6) Start and end date for sump cleanout and problems encountered

I. INTRODUCTION

Exploration coreholes at the Doe Run Mines are currently sealed by mine personnel. This practice has been in place for many years. New coreholes that are encountered during mining operations and that produce significant flows to the mine will be sealed, if sealing is technically feasible. This standard operating procedure provides a decision framework and guidelines for monitoring and sealing coreholes when they are encountered during mining operations.

II. MATERIALS

The following materials, as required, will be used when coreholes are encountered:

- Any necessary safety equipment;
- 55 gallon drum or other similarly sized container of known volume;
- 5 gallon bucket or similar smaller container;
- Stopwatch;
- Measuring tape;
- Field log;
- Mine map;
- Camera.

III. PROCEDURES / GUIDELINES

When a corehole is encountered during mining operations the following procedures shall be used:

A. Determine flow rate from corehole

1) Flowrate from the corehole will be estimated by measuring the time required to fill a 55 gallon drum or other similarly sized container of known volume.
2) If the location of the corehole prevents the use of a 55 gallon drum or if the flow is too small for filling of a 55-gallon drum to be practical, then a 5 gallon bucket or similar smaller container will be used.
3) If, due to the quantity of flow or for safety reasons, it is not possible to measure the flow, this should be reported to the underground water management team who will determine an alternate flow estimation method.
4) Because flows often change after coreholes are encountered, the flow rate will be measured once per month for three months to obtain a better estimate of its long-term flow.

B. Measure the corehole diameter

1) The diameter of the corehole will be measured to the nearest inch.
2) If it is infeasible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.

C. Determine if sealing is required and feasible

1) If the flow from the corehole exceeds 25 gallons per minute the corehole will be sealed.
2) The underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past.
3) If it is unclear whether sealing is feasible, the underground water management team will consult with manufacturer's representatives for mechanical plugs and grouts to help

determine the feasibility of sealing the corehole.

D. Seal the corehole

If it has been determined that the corehole can be sealed, the underground water management team will determine a schedule for the sealing work and ensure that the work is completed.

E. Documentation

The following information must be recorded in writing and submitted to the underground water manager:

1) Corehole discovery time and date.
2) Location of corehole recorded on map
3) Diameter of corehole
4) Measured flowrate – record procedure and results
5) Determination of sealing requirement
6) Problems encountered with sealing determination
7) Communication with the underground water management team
8) If the corehole cannot be sealed – record the reasons for that determination
9) Methods and procedures of corehole sealing
10) Problems encountered in the sealing process and apparent success
11) Sealing completion time and date.
12) Pictures of the corehole will also be taken and kept with the field log.

APPENDIX D:

UNDERGROUND WATER CONTROL MEASURE INSPECTION FORM

This page is blank to facilitate double sided printing.

Underground Water Management Inspection

Date: ______________________ **Inspection By:**______________________

Mine: ____

Notes: ____

Sumps

Sump ID/Location	Water Level	Depth to Sediment	Notification Date

Notes: ____

____

____

Piping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

Underground Water Management Inspection

Date: ______________________ **Inspection By:**_______________________

Roadways

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

BMPs/General Housekeeping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

EXHIBIT L

UNDERGROUND WATER MANAGEMENT PLAN for the BUICK MINE

Prepared for: **The Doe Run Resources Corporation d/b/a The Doe Run Company**

January 30, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix A: Buick Mine Water Flow Map with Lead and Zinc Sampling Results
Appendix B: Vendor Information on Grout Used for Corehole Sealing
Appendix C: Standard Operating Procedures
Appendix D: Underground Water Control Measure Inspection Form

1. INTRODUCTION

This document presents the Underground Water Management Plan (UGWMP) for the Buick Mine, prepared on behalf of the Doe Run Resources Corporation, d/b/a/ The Doe Run Company (DRC). The Buick UGWMP has been prepared in accordance with the Master UGWMP previously prepared by Resource Environmental Management Consultants, Inc. In keeping with the Master UGWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Buick Mine is located in Iron and Reynolds Counties, Missouri, approximately 7 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Buick Mine (USGS, 2008).

Year	Event
1960	Deposit was discovered.
1966	Tailings dam was constructed.
1969	Mine opened for production as a joint venture of Amax Inc. and Homestake Mining Company. Production started under the name Missouri Lead Operating Company. Mill also constructed.
1986	Production was suspended then resumed during ownership transition.
1990/91	The mine was purchased by Doe Run.

The Buick Mine is located centrally within the Viburnum Trend. Mining operations occur approximately 1,100 feet below ground surface.

1.2 OBJECTIVES

As stated above, the main objective of this UGWMP is to evaluate the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility. This main objective is met through the following:

- Understanding of the sources, quantity and movement of water through the mine.
- Understanding of the quality of water entering, moving through, and leaving the mine, with respect to the target constituents of interest.

- Identification and evaluation of potential control measures for reducing water volumes, metals concentrations, or both in the mine.

Each of these items is discussed in this plan. The UGWMP also presents an assessment of the technical feasibility of various potential control measures for the Buick Mine, as well as a plan for further investigation or implementation of potentially technical feasible control measures, based on whether such measures are likely to reduce metals loading and whether they are cost-effective.

1.3 UNDERGROUND WATER MANAGEMENT TEAM

Underground water management for the Buick Mine will be the responsibility of the individuals named in Table 1-2.

Table 1-2. Buick Mine Underground Water Management Team.

Job Title	Name	Contact Information	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	P.O. Box 500 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mine Manager	Greg Sutton	P.O. Box 500 Viburnum, MO 65566 573-626-2001	Oversight and management of Doe Run Mining Operations
Buick General Mine Supervisor	Jeff Gibson	270 Forest Road 2331 Highway KK Boss, MO 65440 573-626-2055	Buick UGWMP Primary Oversight, Implementation, and Record-Keeping
Buick Mine Superintendent	Randy Hanning	270 Forest Road 2331 Highway KK Boss, MO 65440 573-626-2106	Buick UGWMP Secondary Oversight, Implementation, and Record-Keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573-689-4535	Environmental data collection, management, and reporting

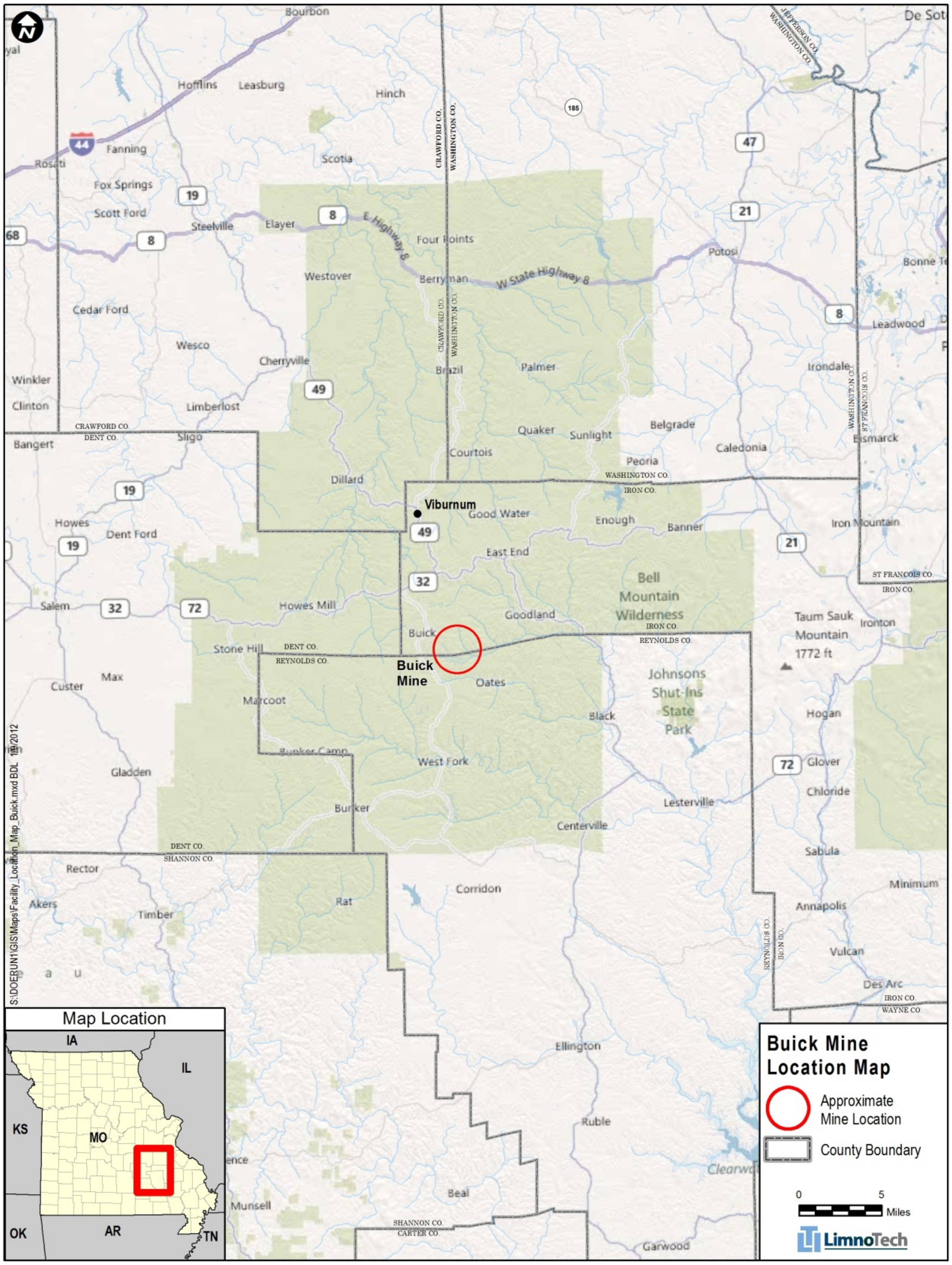


Figure 1-1. Location of the Buick Mine.

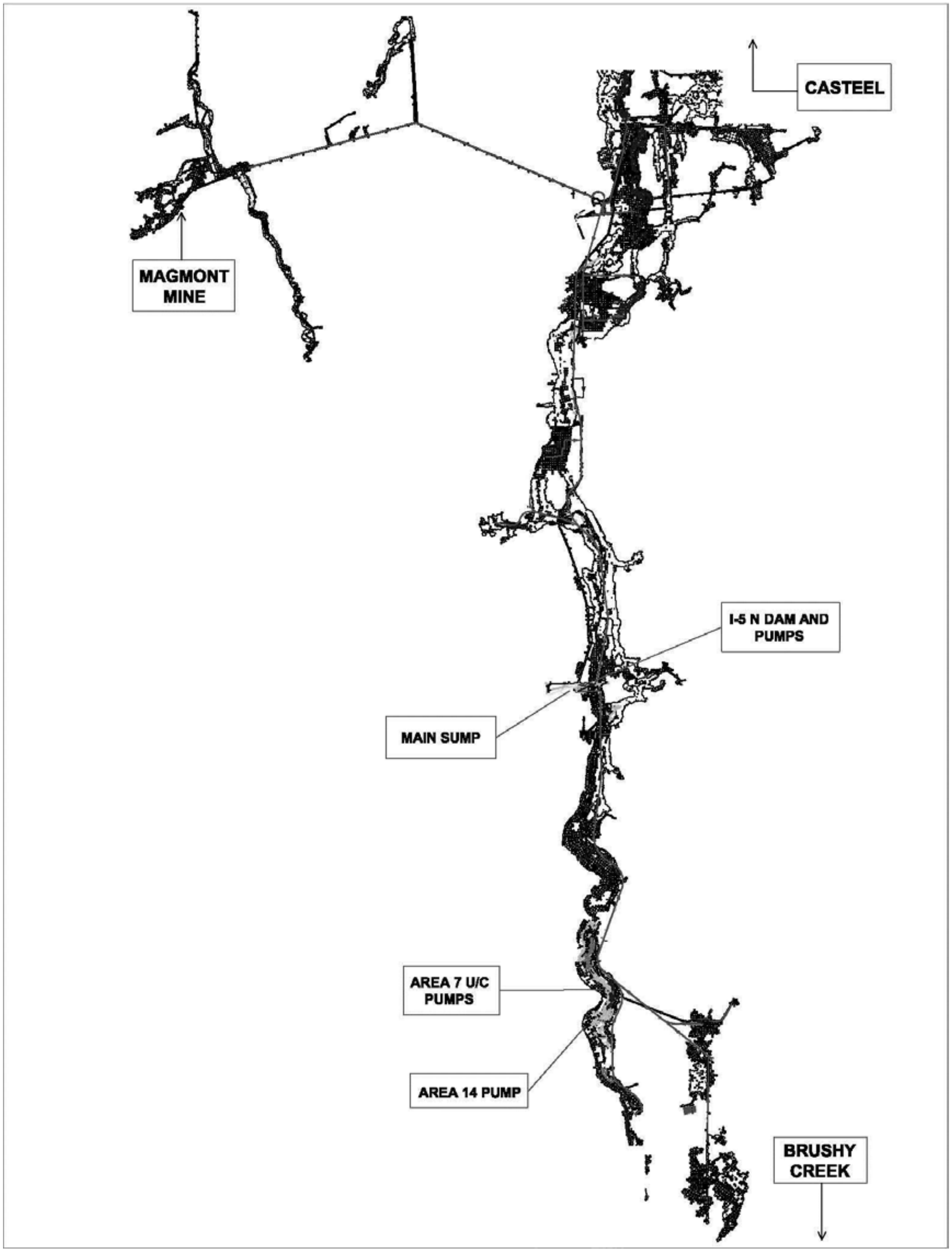


Figure 1-2. Layout of the Buick Mine.

2. SUMMARY OF MINE WATER DATA

The Master UGWMP outlined the hierarchy of water management priorities listed below from highest priority to lowest.

1. Source Control
2. Water Minimization
3. Reuse or Reclamation
4. Water Treatment
5. Discharge

Because source control has been identified as the first water management priority, source identification is a fundamental part of the planning effort for potential measures to control metals loading. Load is a function of both flow and concentration. Therefore, these components were each examined independently at the Buick Mine, as described below.

2.1 WATER SOURCES AND MOVEMENT

An inventory of water in the Buick Mine was compiled for this plan based on the best available information and includes the following components:

- Total mine water flows
- Sources of mine water
- Current underground management of mine water

Each of these components is described below.

2.1.1 Total Mine Water Flows

Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Buick Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-1.

Table 2-1. Mine Water Flowrates at Buick Mine.

Quantity	Value
Maximum Mine Water Pumping Capacity (current)	9,000 gpm
Average Flow Pumped to Surface (current)	3,000-6,000 gpm*
*Pumping rates vary over time. Flows shown in Figure 2-1 were measured on 12/20 and 12/21/11 and reflect total mine water flow of approximately 4,000 gpm into the main sump.	

Flow data are not currently recorded at the mine water sump, but are estimated from pump capacities and historical measurements. The average flow reported in Table 2-1 represents Doe Run's best estimate based on available information. The maximum pumping capacity is based only on pump capacity and does not reflect maximum flows actually pumped from the mine. It is known that flow rate can vary over time depending on factors such as season or where the mine is being advanced, however the values in Table 2-1 represent the best available estimate. Also, as indicated in Table 2-1, approximately 1,000 gpm of mine water was previously pumped from Casteel mine to Buick mine. A new mine water sump was constructed in Casteel mine, called the V10 sump, and became fully operational by January 2012. The V10 sump increased the mine water pumping capacity at Casteel by 3,000 gpm. The additional mine water handling capacity in Casteel mine resulting from this project eliminated the need to transfer mine water from Casteel to Buick. Therefore, the mine water previously pumped to the Buick mine is now diverted to the Casteel Lower Main Sump. This reduced average mine water flows from Buick mine by about 1,000 gpm.

2.1.2 Sources of Mine Water

Water enters the Buick Mine mainly through general seepage, with some minor flows from shafts. Given the diffuse nature of most water entering the mine it is difficult, if not impossible, to accurately measure all sources. However, mine water flows were measured to support preparation of this plan at some key locations in the Buick Mine. Based on these flow measurements and information provided by Doe Run personnel, the major flow distribution of mine water pumped to the surface at Buick is as follows:

- Approximately one half of the total mine water flow at Buick (approximately 1,400 gpm on average) is from the north mine.
- Approximately one half of the total mine water flow at Buick (approximately 1,300 gpm on average) is from the south mine.
- Of the flow from the north mine, approximately 1,000 gpm comes from the Magmont mine to the northwest and prior to the installation of the V10 sump at the Casteel Mine, approximately 1,000 came from the Casteel mine. Currently, approximately 50% of the mine water flows from the north mine to the main mine water sump at Buick.

The flow distribution is depicted schematically in Figure 2-1. Flow measurements were collected by Doe Run and LimnoTech staff at several locations in Buick Mine on December 21 and 22, 2011 as shown in Figure 2-1. Flow measurements were also collected by Doe Run on September 17, 2012 which indicated that the V10 Sump installation at Casteel reduced the flow to Buick by approximately 1300 gpm. Measurements were collected using a velocity meter and measuring tape. The measurements provide an indication of flowrates for those days and corroborate the previous estimates.

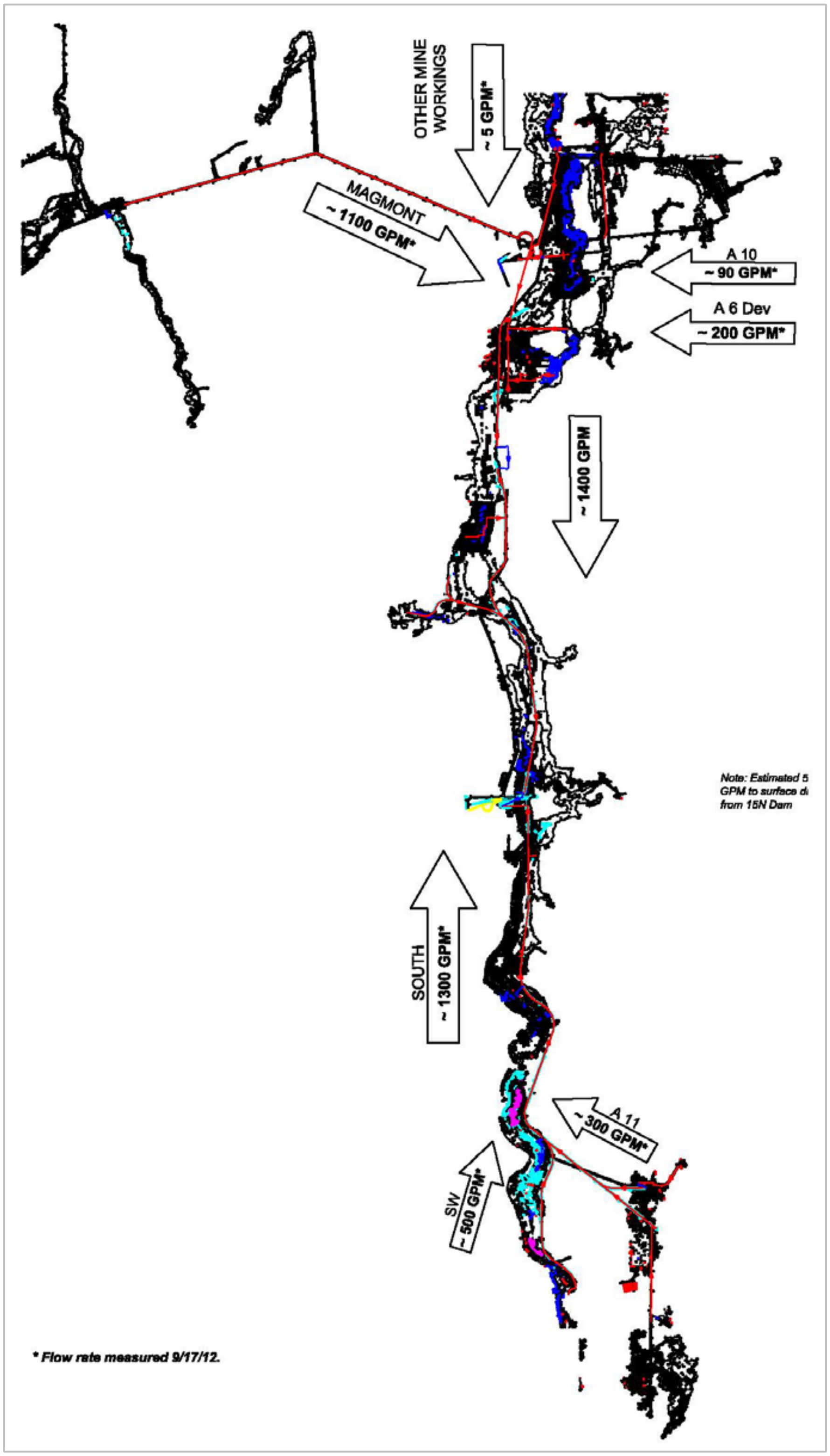


Figure 2-1. Measured Mine Water Flows for the Buick Mine on December 20 and 21, 2011.

2.1.3 Current Underground Water Management Practices

Current practices to manage mine water at Buick Mine are primarily focused on maintaining safe and workable conditions in the mine and are not specifically designed to maintain or improve water quality. These practices include the following:

- Piping – Piping of water through the mine has historically been performed to facilitate transfer pumping from one location to another, where mine grades prevent gravity flow. Piping is discussed in greater detail in Section 3.1.1.
- Sump cleaning – Sump cleaning, or mucking as it is called by mine personnel, has historically been performed, as needed, to maintain performance of the mine water sump pumps. Sump mucking is discussed in greater detail in Section 3.4.9.

Although it may not be their specific intent, these practices may have an incidental benefit of protecting water quality. These and other potential water management practices to preserve or improve water quality are discussed in greater detail in Section 3 of this Plan.

2.2 MINE WATER QUALITY

To support development of this and other water management plans at Doe Run mine/mill facilities, a water quality sampling program was implemented between December 2010 and June 2011. Three rounds of underground water sampling were performed at each mine. The details of the underground sampling program, including the sampling results, are presented in the Underground Water Sampling and Analysis Plan Report (LimnoTech, August 4, 2011). Sampling locations for these events are shown in Figure 2-2. A more complete map of Buick Mine showing sample locations, water flow paths, pump information, and sampling results for total and dissolved lead and zinc, is included as Appendix A.

These data were evaluated to better understand mine water quality at Buick Mine and to discern factors that may improve or degrade mine water quality. Because the purpose of this UGWMP and the surface water management plan at Buick is to be part of a comprehensive effort above and below ground to attain compliance with Missouri State Operating Permit (MSOP) final limits for the discharge of mine water and other sources to waters of the State, the mine water data were evaluated in reference to the final discharge limits in the MSOP for the Buick Mine. The final limits for the primary constituents of interest for outfall 002 are summarized in Table 2-2.

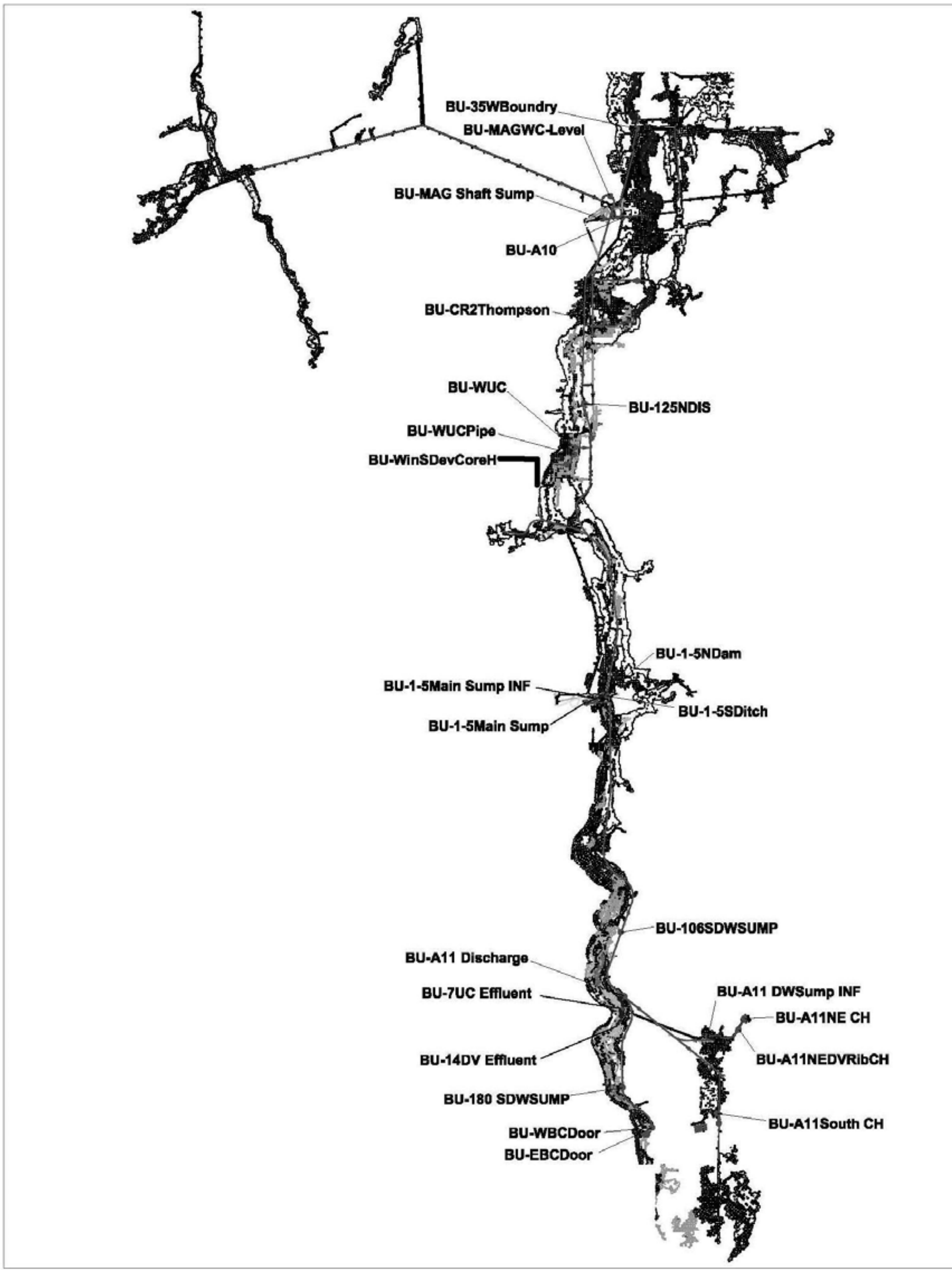


Figure 2-2. Mine Water Sampling Locations for the Buick Mine.

Table 2-2. Final MSOP Limits for the Buick Mine (Outfall 002).

Parameter	**Final Effluent Limits**	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.2	0.6
Copper, total recoverable	85.8	42.8
Lead, total recoverable	56.6	28.2
Zinc, total recoverable	434.5	216.5

The findings of this evaluation are presented in the following sections.

2.2.1 Incoming Mine Water Quality

Incoming mine water quality at Buick Mine is characterized by samples collected at four locations: “A11NE CH”, “A11NEDVRibCH”, “A11South CH” and “WinSDevCoreH”. All samples denoted with “A11” correspond to incoming mine water at the southeast portion of the mine. The sample WinSDevCoreH was located near the window undercut and represents water flowing from the borehole in the back. It is the only sampling location representative of incoming mine water north of the main sump. It should be noted that since sampling of WinSDevCoreH in 2011, pillar extraction was conducted in that part of the mine and the area is now open stope, making the WinSDevCoreH location inaccessible.

Three samples each from WinSDevCoreH and one sample from each of the remaining incoming mine water samples were taken during the underground sampling program. The data are represented in Table 2-3.

Comparing these results to the final discharge limits presented in Table 2-2 shows that, in general, concentrations of primary metals in incoming mine water are generally below the final permitted discharge limits, with the following exceptions:

- The total cadmium results for all three samples collected at WinSDevCoreH exceeded both the daily maximum and monthly average final discharge limits for cadmium.
- One sample collected at WinSDevCoreH exceeded the final monthly average discharge limit for lead.
- All three samples collected at WinSDevCoreH exceeded both the daily maximum and monthly average final discharge limits for zinc.

No samples exceeded monthly average or daily maximum copper or TSS final discharge limits. It is expected that incoming mine water is in the south mine is more accurately represented by the samples from A11NE CH, A11NEDVRibCH, and

A11South CH. The elevated cadmium and zinc concentrations at WinSDevCoreH could be a function of the rock strata through which the water flows before entering the mine. It is not certain that all water entering the mine will have the same quality as is reflected in these samples.

Table 2-3. Incoming Mine Water Quality at Buick Mine.

Location	Sampling Date	Parameter				
		Total Cadmium (μg/L)	Total Copper (μg/L)	Total Lead (μg/L)	Total Zinc (μg/L)	TSS (mg/L)
A11NE CH	2/15/2011	ND (0.08)[1]	ND (0.5)	ND (0.1)	ND (5)	ND (5)
A11NEDVRibCH	2/15/2011	ND (0.08)	ND (0.5)	0.92	ND (5)	ND (5)
A11South CH	2/15/2011	ND (0.08)	ND (0.5)	0.43	ND (5)	ND (5)
WinSDevCoreH	2/15/2011	13.5	ND (0.5)	6.2	809	ND (5)
WinSDevCoreH	3/23/2011	8.3	0.98	26.5	548	ND (5)
WinSDevCoreH	6/7/2011	16	2.9	33	1436	ND (5)

2.2.2 Comparison of Incoming and Outgoing Mine Water

Inspection of the water data collected throughout Buick Mine shows that samples at many locations contain concentrations of target metals above the final permitted effluent limits, so incoming and outgoing mine water (i.e., mine water pumped to the surface) were compared to discern which of those metals exceed their respective final discharge limits.

These comparisons of samples taken of incoming mine water at A11NE CH, A11NEDVRibCH, A11South CH and WinSDevCoreH with mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-3, 2-4, 2-5, and 2-6, respectively. As stated above, incoming mine water quality is characterized by samples collected at A11NE CH, A11NEDVRibCH, A11South CH and WinSDevCoreH.

Outgoing mine water is characterized by the sample collected at 1-5Main Sump. Three samples were collected at each of these locations in the initial sampling program and an additional seven samples were collected from February to August 2012. The following observations can be made from the data shown in Figures 2-3, 2-4, 2-5, and 2-6:

- Cadmium: All three incoming mine water samples from WinSDevCoreH exceed both the monthly average and daily maximum cadmium final effluent limits for outfall 002. Final limits were also exceeded in the mine water sump sample.

[1] ND indicates that the parameter was not detected at the analytical detection limit shown in parentheses.

- Copper: All samples of incoming mine water were well below the final effluent limits for copper. The mine water sump sample exceeded both the monthly average and daily maximum final limits for copper.
- Lead: One of the three samples at WinSDevCoreH exceeded the final monthly average lead limit; the other two samples fell below both limits. The remaining incoming mine water locations sampled did not exceed the final limits during the sampling program. The mine water sump sample exceeded both the monthly average and daily maximum final limits for lead.
- Zinc: Incoming mine water samples were below the final effluent limits for zinc with the exception of the three samples at WinSDevCoreH, which exceeded both the monthly average and daily maximum final effluent limits for zinc. The mine water sump sample exceeded both the monthly average and daily maximum limits for zinc.

These results suggest that exposure of mine water to the mine workings at Buick can result in significant degradation of water quality, in part likely due to the increase in total suspended solids. The relationship between increased metals concentrations and increased suspended solids in mine water is discussed in Section 2.2.4 of this plan.

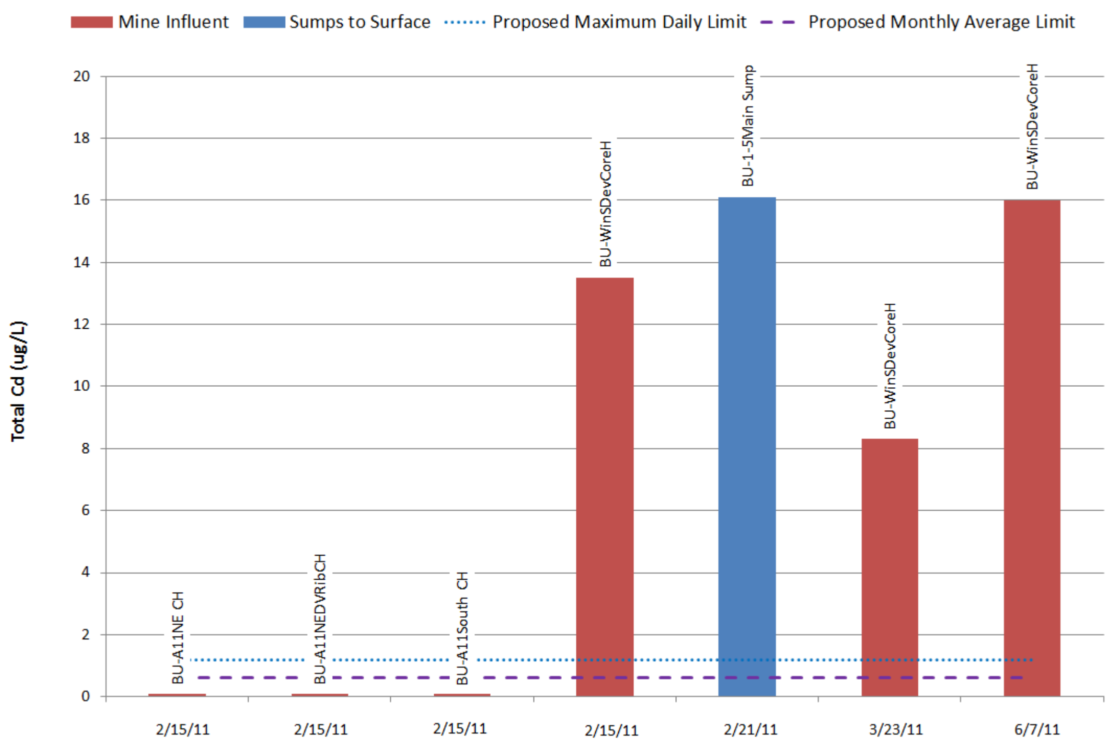


Figure 2-3. Incoming vs. Outgoing Mine Water Quality at Buick Mine: Total Cadmium.

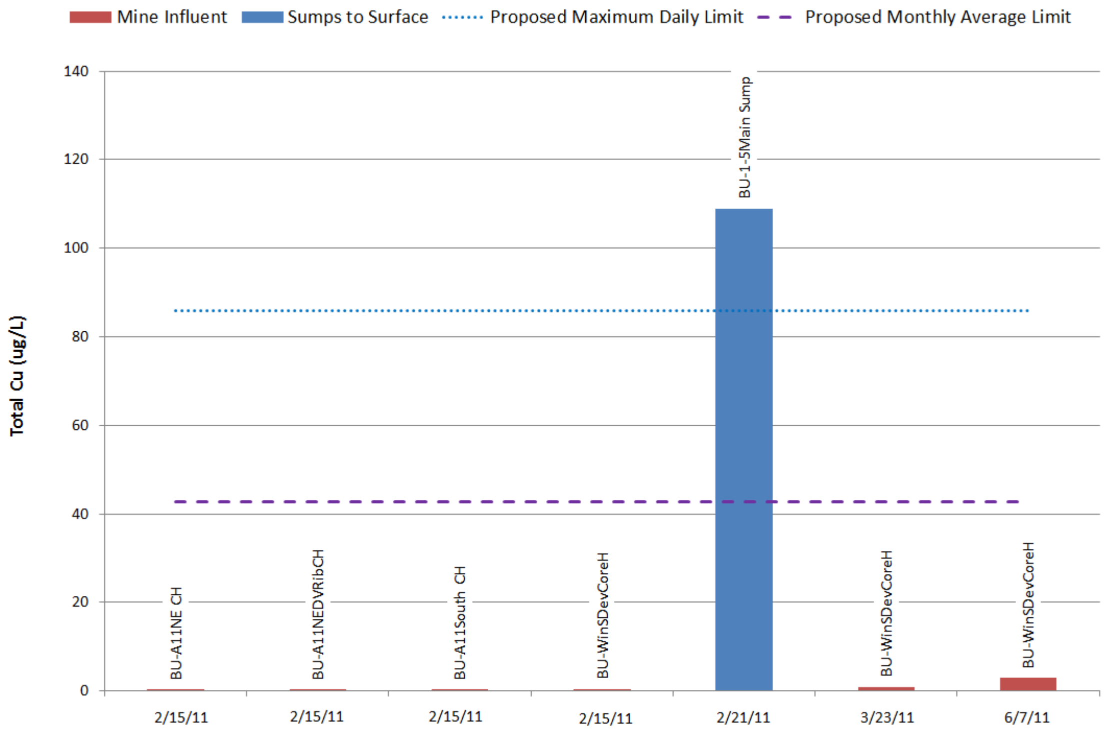


Figure 2-4. Incoming vs. Outgoing Mine Water Quality at Buick Mine: Total Copper.

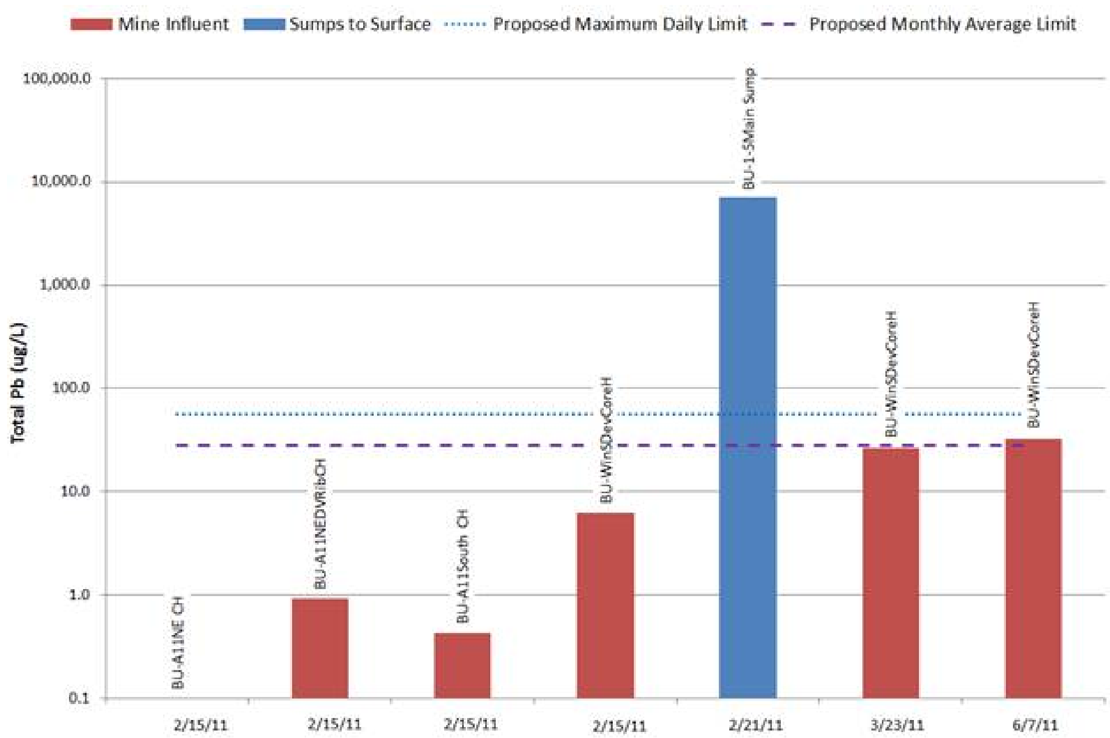


Figure 2-5. Incoming vs. Outgoing Mine Water Quality at Buick Mine: Total Lead (Note: log scale).

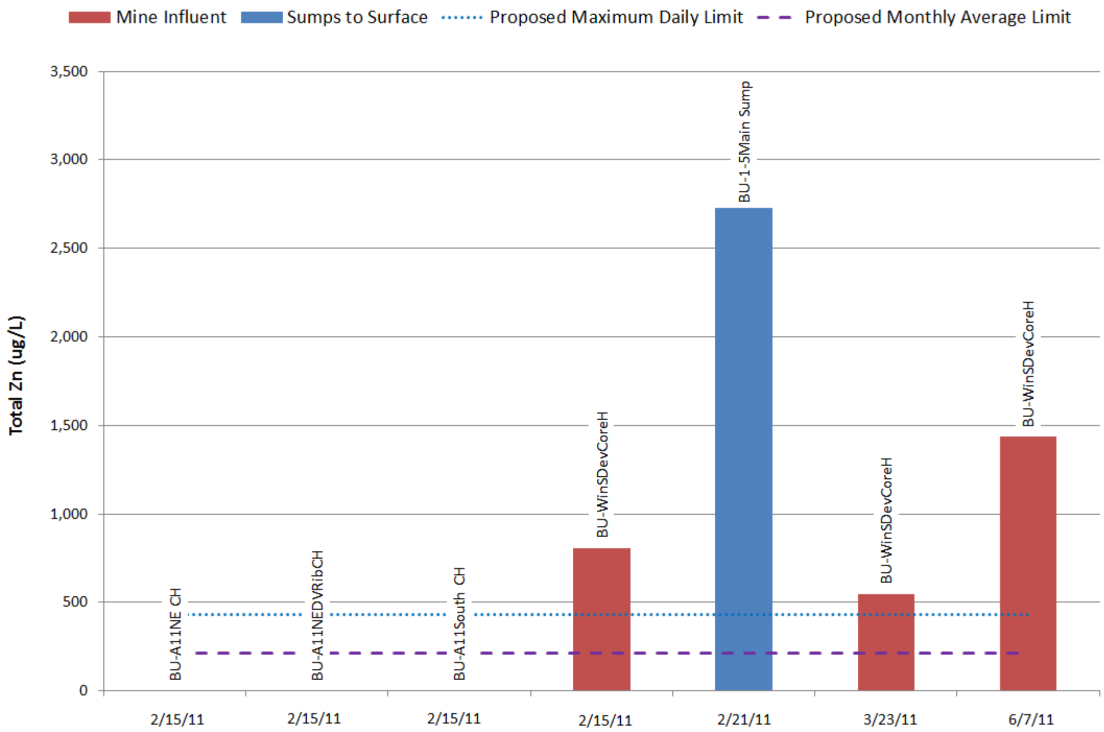


Figure 2-6. Incoming vs. Outgoing Mine Water Quality at Buick Mine: Total Zinc.

2.2.3 Spatial Variation in Mine Water Quality

Most of the mine water that is currently pumped to the surface at Buick comes from the north end of the mine. However, although the north mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the three parts. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the north and south were compared. The north mine sampling locations include 125NDIS, CR2Thompson, A10, 35WBoundary, MAG Shaft Sump, MAGWC-Level, WUC, WUCPipe, 1-5NDam, 125NDIS and 1-5Main Sump INF. The south mine sampling locations include 1-5SDitch, 106SDWSUMP, 14DV Effluent, WBCDoor, 7UCEffluent, A11 Discharge, 180 SDWSUMP, EBCDoor, and A11 DWSump INF. Figures 2-7 through 2-10 show the comparison box plots of mine water quality between the north and south parts of Buick mine. The box plots can be interpreted as follows:

- The dash in the center of each box represents the median value of the data set.
- The lower and upper edges of the box are the first and third quartiles (the first quartile represents the value that is equal to or greater than 25% of the data and the third quartile represents the value that is equal to or greater than 75% of the data), respectively.
- The lower and upper whiskers are the 5th and 95th percentile values.

For ease of comparison, each plot also shows the final effluent limits for that metal in the MSOP. The following observations can be made from these plots:

- Cadmium: Cadmium tends to occur at slightly higher concentrations in the north mine than in the south mine, with the north mine median concentration (6 μg/L) being three times the south mine median (2 μg/L) and nearly equal to the maximum value detected in the south mine (7 μg/L). All mine water samples in the north mine exceeded both the monthly average and daily maximum cadmium final effluent limits. Most (71%) samples in the south mine exceeded the final monthly average final effluent limit and about half (51%) exceeded the final daily maximum limit.
- Copper: Copper in the north occurs at higher concentrations than in the south mine; the median concentration in the north (23 μg/L) is significantly higher than the median for the south (3 μg/L). Only about 13% of the samples from the north mine exceeded the final daily maximum limit and 32% exceeded the final monthly average limit. All of the samples from the south mine were below both the monthly average and daily maximum final limits.
- Lead: Most mine water samples exceeded both the monthly average and maximum daily final effluent limits. In the north mine, 65% exceeded the final daily maximum limit and 90% exceeded the final monthly average limit. In the south mine, 81% exceeded the final daily maximum limit and 84% exceeded the final monthly average limit. Overall, there does not appear to be a significant difference between the north and south mines at Buick, with respect to lead in mine water.
- Zinc: Zinc concentrations appear to be slightly higher in the north mine than in the south mine. In the north mine, 94% of mine water samples exceeded the final daily maximum limit and 100% exceeded the final monthly average limit. In the south mine, about half (52%) of the samples exceeded the final daily maximum limit and 74% exceeded the final monthly average limit.

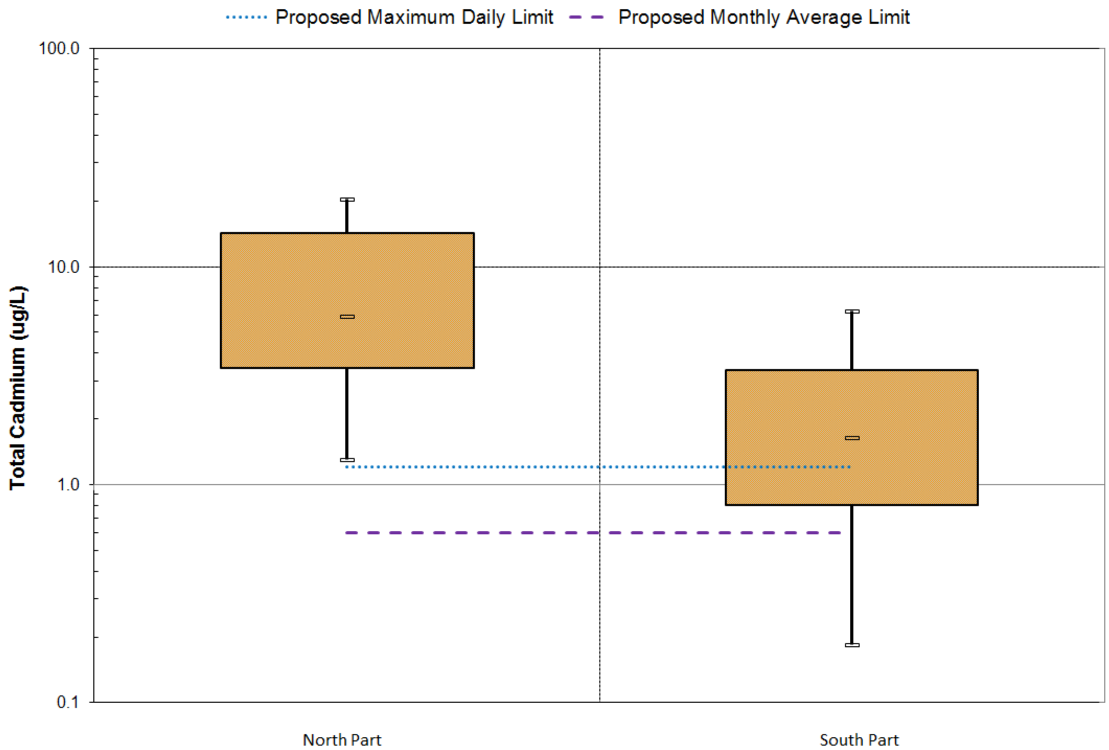


Figure 2-7. Comparison of Total Cadmium between North and South Parts of Buick Mine.

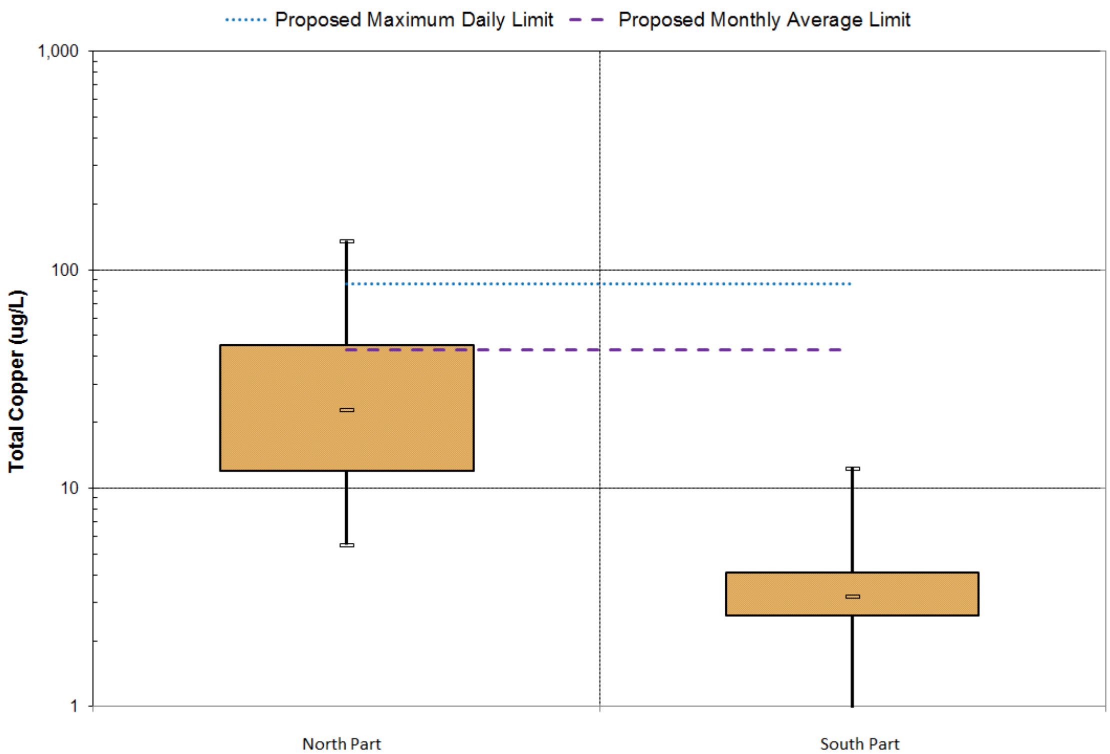


Figure 2-8. Comparison of Total Copper between North and South Parts of Buick Mine.

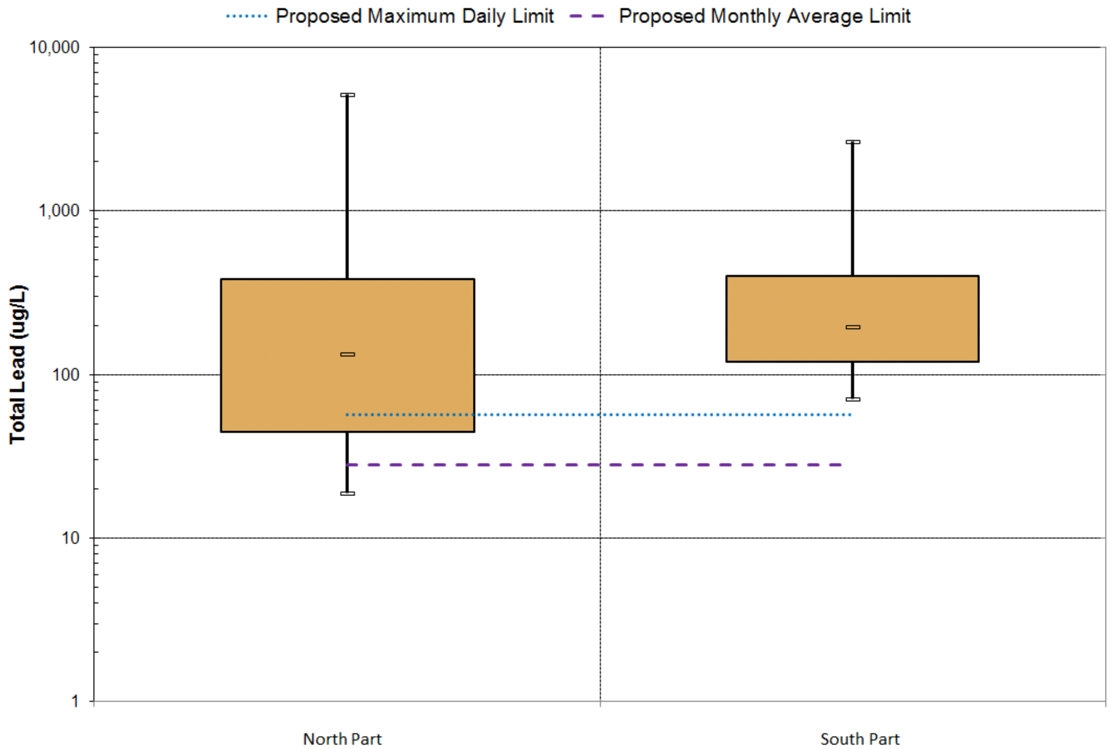


Figure 2-9. Comparison of Total Lead between North and South Parts of Buick Mine.

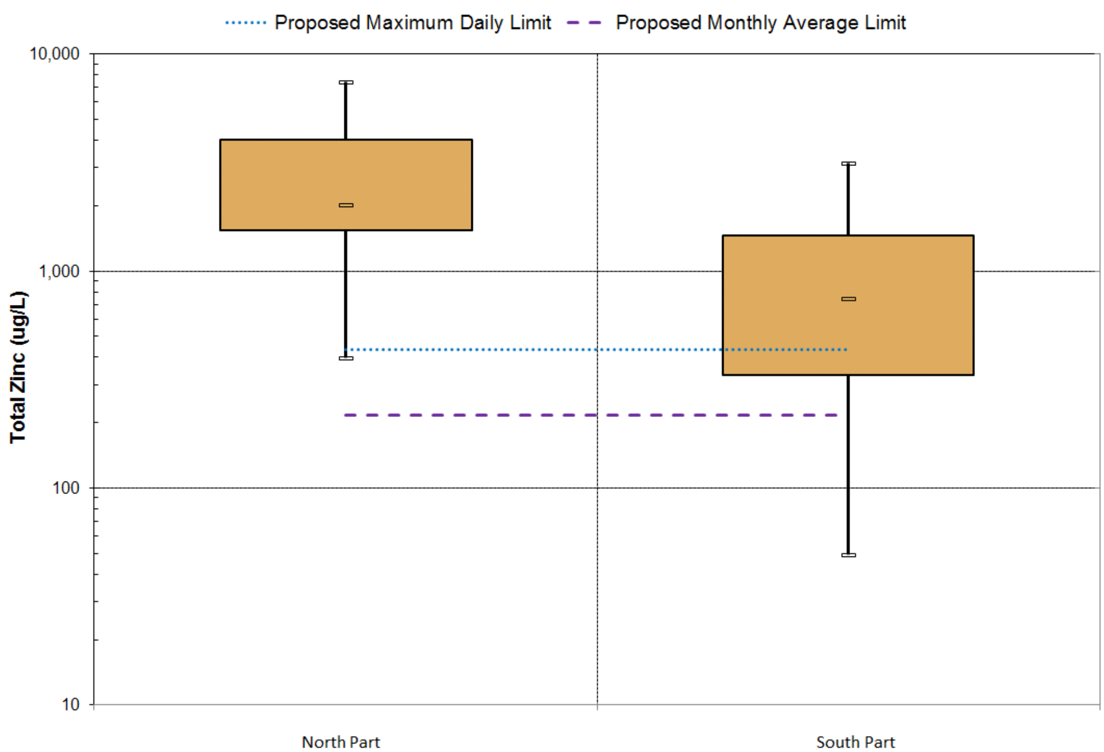


Figure 2-10. Comparison of Total Zinc between North and South Parts of Buick Mine.

2.2.4 Relationship Between Solids and Metals in Mine Water

Data from the Buick Mine show that, in general, incoming mine water has relatively low metals concentrations compared to mine water that is pumped to the surface and that the concentrations of metals are significantly increased by exposure to the mine workings (Section 2.2.2). Therefore, the Buick Mine data were evaluated to assess the relationship between metals and suspended solids. Figures 2-11 through 2-14 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS). These results show varying relationships of metals with TSS at Buick mine. The correlations are summarized in Table 2-4.

Table 2-4. Correlations of Total Metals with Total Suspended Solids at Buick Mine.

Parameter	Correlation with TSS (r^2 value)
Cadmium, Total	0.50
Copper, Total	0.30
Lead, Total	0.29
Zinc, Total	0.33

The r-squared values[2] in Table 2-4 indicate that total metals are positively but not strongly correlated to TSS. This suggests that increases in TSS, resulting from exposure of incoming mine water to mine workings, are a small contributor to increases in metals concentrations at Buick. The apparently weak relationship between total lead and TSS at the Buick mine is contrary to what is observed at other Doe Run mines, where a much stronger relationship is observed.

[2] One way of interpreting r^2 values is that if total cadmium has an r^2 value of 0.50 with TSS, then TSS explains 50% of the variability of total cadmium in the data set.

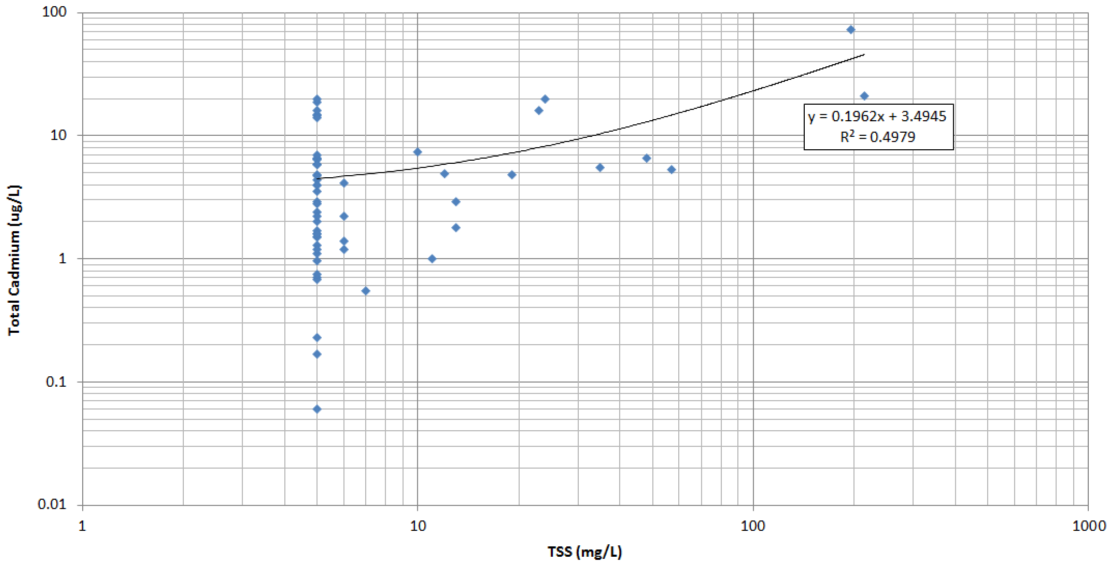


Figure 2-11. Correlation of Total Cadmium with Total Suspended Solids at Buick Mine.

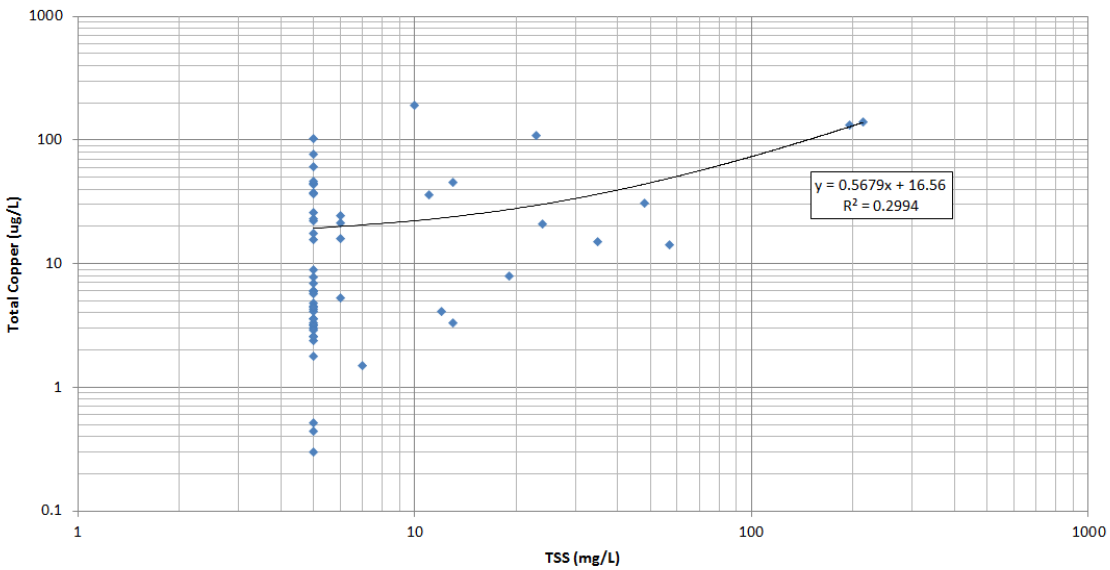


Figure 2-12. Correlation of Total Copper with Total Suspended Solids at Buick Mine.

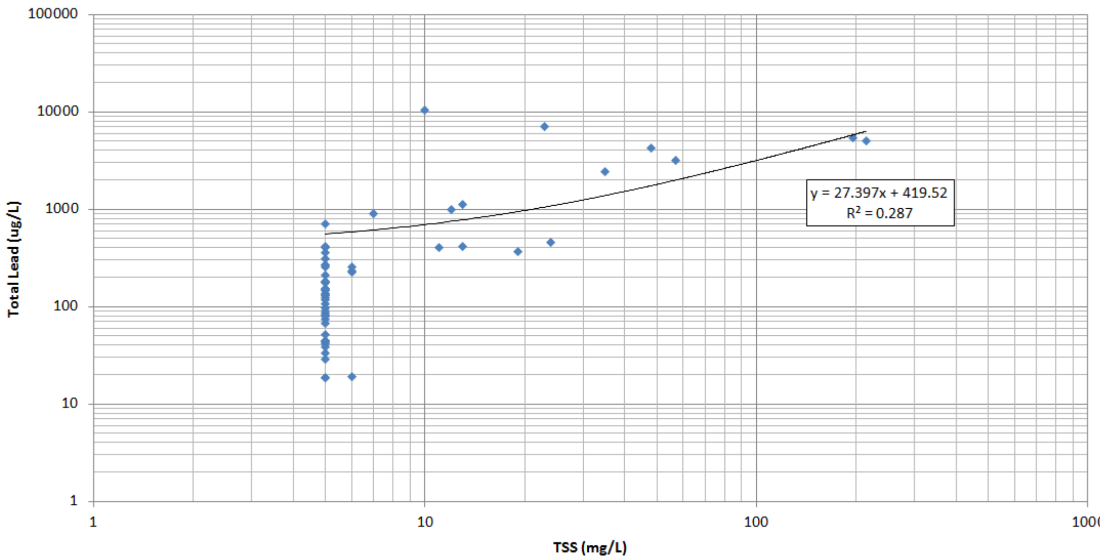


Figure 2-13. Correlation of Total Lead with Total Suspended Solids at Buick Mine.

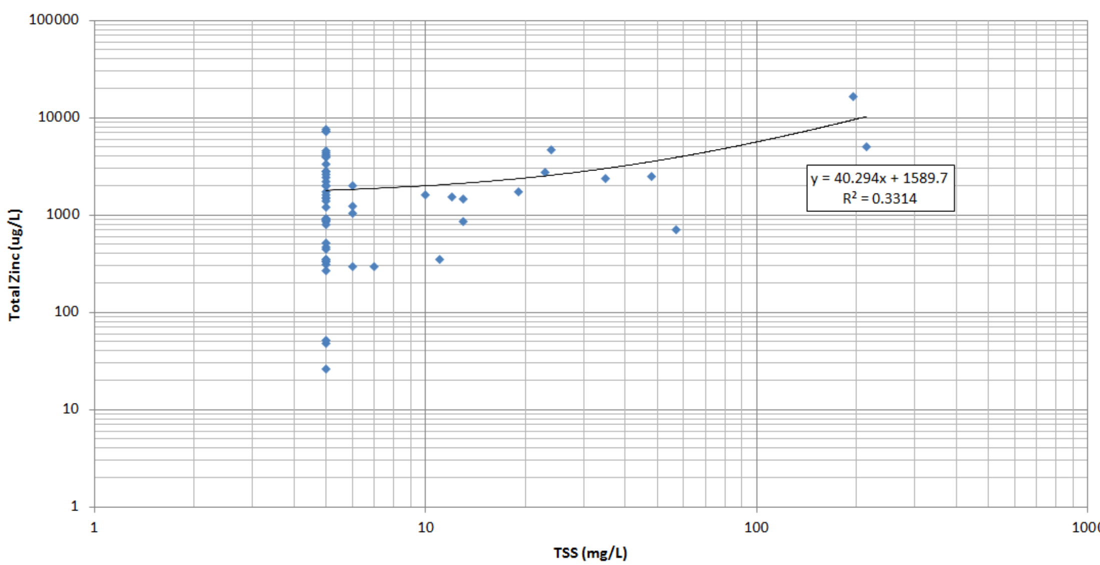


Figure 2-14. Correlation of Total Zinc with Total Suspended Solids at Buick Mine.

2.2.5 Comparison of Underground and Surface Mine Water

Mine water data at the underground sump at Buick were compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. Mine water data at the surface is represented by samples taken at the mine water tank. The results are plotted in Figures 2-15 through 2-18 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is not possible because the underground and surface samples were not collected on the same dates and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made. Specific observations are as follows:

- Cadmium in the mine water sump and at the surface exceeds both the monthly average and daily maximum final limits in all samples.
- Copper in the mine water sump and half the samples at the surface exceeds both the monthly average and daily maximum final limits. The 2/16/2011 sample at the mine water tank exceeds both limits.
- Lead in the mine water sump and at the surface exceeds the monthly average and daily maximum final limits in all samples.
- Zinc in the mine water sump and at the surface exceeds the monthly average and daily maximum final limits in all samples, with the 2/16/2011 sample at the mine water tank far exceeding the limits.

Ongoing sampling at Buick mine will include underground and surface mine water and these data will continue to be evaluated as they become available.

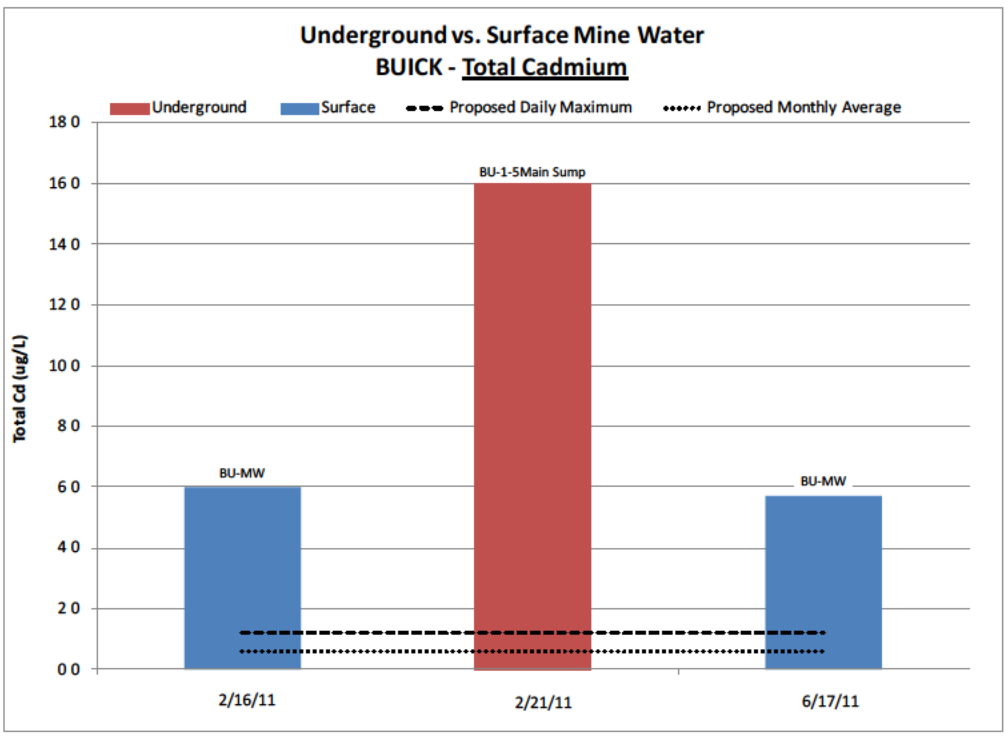


Figure 2-15. Total Cadmium in Underground vs. Surface Mine Water at Buick Mine.

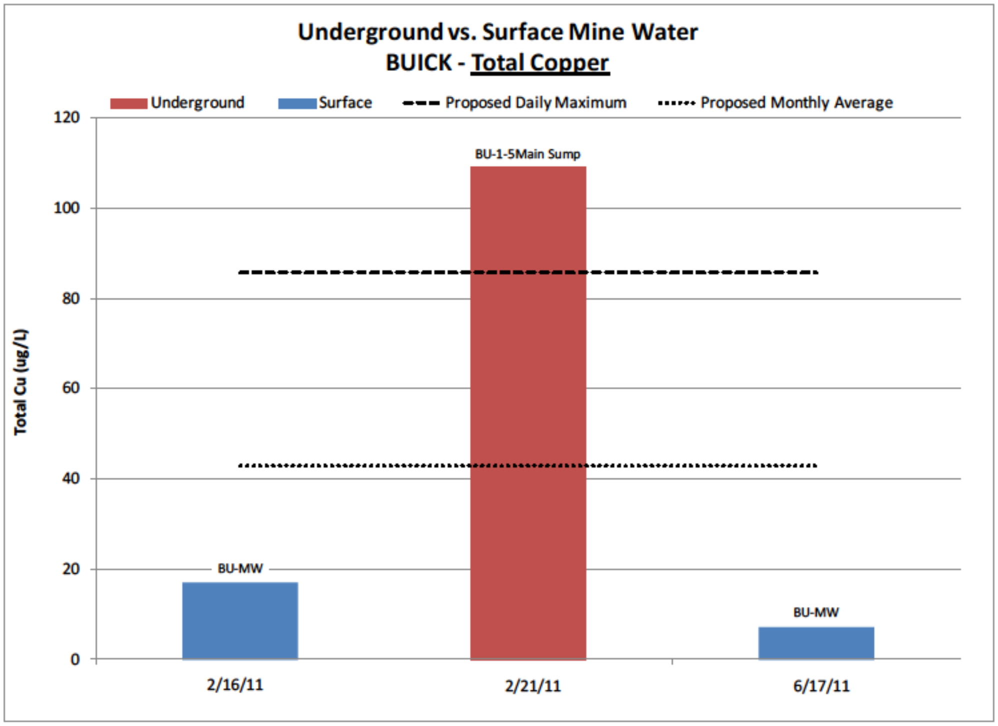


Figure 2-16. Total Copper in Underground vs. Surface Mine Water at Buick Mine.

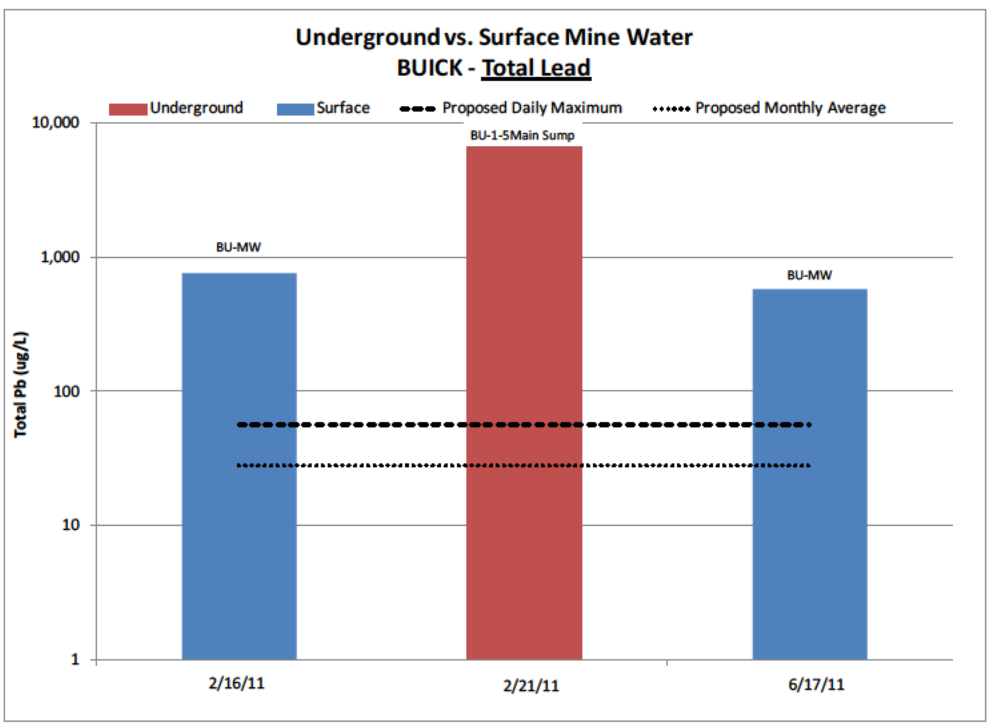


Figure 2-17. Total Lead in Underground vs. Surface Mine Water at Buick Mine.

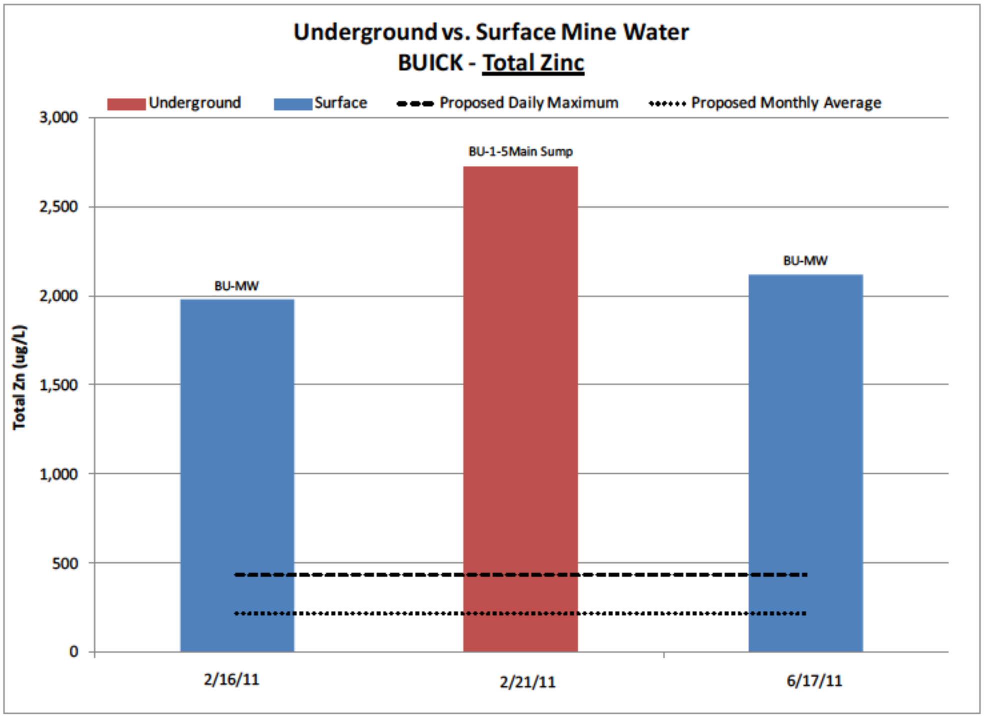


Figure 2-18. Total Zinc in Underground vs. Surface Mine Water at Buick Mine.

2.3 SUMMARY OF MINE WATER SOURCES AND CONDITIONS

The findings of the preceding discussion of mine water at Buick Mine can be summarized as follows:

- The average flow of water entering Buick Mine and being pumped to the surface is estimated at 3,000 gpm. Of this total mine water flow, approximately one half (1,500 gpm) of the flow comes from the north part of the mine and one half of the flow comes from the south part of the mine.
- Incoming mine water, with the exception of WinSDevCoreH, has relatively low metals concentrations, and exposure to the mine workings increases those concentrations.
- Total cadmium, copper, lead and zinc appear to be positively correlated with total suspended solids, but the relationship between these metals and total suspended solids at Buick appears to be weaker than observed at other mines.
- In general, concentrations of total cadmium, copper, lead and zinc in mine water at Buick have the likelihood to exceed final effluent limits.
- Mine water data collected to date do not indicate pronounced differences in lead concentrations between the north and south parts of the Buick mine, but cadmium, copper and zinc tend to be higher in mine water in the north.

Some possible water management approaches for Buick mine for consideration as a result of these findings, include:

- Evaluate the effectiveness, technical feasibility and cost-effectiveness of measures that minimize exposure of water entering the mine to mine workings.
- Evaluate options that are effective, technically feasible and cost-effective to minimize the introduction of suspended solids to mine water in an effort to reduce metals concentrations.

These water management approaches were used to evaluate potential water management measures, as discussed in Section 3.

3. WATER MANAGEMENT MEASURES

This section of the plan presents several potential water management strategies and evaluates them in the context of Buick Mine. In keeping with the Master Underground Water Management Plan, this section discusses the following types of possible measures:

- Isolation measures (Section 3.1)
- Treatment measures (Section 3.2)
- Groundwater interception (Section 3.3)
- Best management practices (Section 3.4)

A summary of the evaluation of these measures for Buick Mine is presented in Section 3.5. It should be noted that this Section discusses potential underground water management measures and that these measures are not necessarily all planned for implementation at Buick Mine. Section 4 describes which of these measures are planned for implementation and further evaluation of their effectiveness, technical feasibility, and cost-effectiveness at Buick Mine. It should also be noted that Doe Run is currently evaluating the technical feasibility and probable costs of treating mine water at the surface and these evaluations will provide a point of comparison with potential underground water management measures to evaluate the cost-effectiveness of those measures.

3.1 ISOLATION MEASURES

Isolation measures are practices designed to isolate mine water from materials/processes that have the potential to increase metals in the mine water. The objective of isolation technologies is to eliminate or reduce the potential for mine water to contact or be exposed to environments that have the potential to increase the metals load.

3.1.1 Piping Water

In some locations in the mine, mine water flows via gravity in roadside ditches. In some places in Buick Mine, where it is necessary to pump water due to grade changes, the water flows through pipes. In areas where there is open water in ditches and piping is not used, the water surface is exposed to loading of solids and metals from the roadways, mobilized by passing trucks and machinery. Because of this potential exposure, piping presents a potential control measure for improving water quality.

Parts of Buick Mine that are currently piped are shown on the map in Appendix A. Piping used in the mine typically consists of high density polyethylene (HDPE) pipe, with 8-inch and 10-inch diameter (nom.) being the most common size used for long runs in Doe Run mines. The unit cost for these pipe materials ranges from $7 to $10 per linear foot (l.f.) for 8” pipe and $11 to $17 per l.f. for 10” pipe. These are materials costs based on current vendor pricing and do not include labor for installation.

Review of sampling data from Doe Run mines shows that water quality is reduced within a short distance of water entering the mine. This suggests that, for piping to be an effective control measure, water must be captured very close to the source before significant exposure to mine workings occurs. This is not possible in most circumstances. However, piping may be implemented on a localized basis at the Buick Mine as a water quality management measure where the company determines that the measure will be effective in controlling water quality and will be cost-effective.

3.1.2 Lined Channels

Roadside channels in the mine allow contact between flowing water and the underlying rock. This contact may cause an increase in metals concentration, so lining of the channels was evaluated. Lining would involve placement and anchoring of an impermeable material on the bottom of the ditch to prevent the water-rock contact. This approach has not been tested but may be less effective than piping because it only addresses the issues of contact between flowing mine water and underlying rock, whereas piping should isolate mine water from the surrounding mine workings, as well as the underlying rock. In addition, sediment could likely accumulate in the lined channel over time and defeat the purpose of the lining. For these reasons, channel lining is not considered for evaluation as a potential water quality control measure for Buick Mine.

3.1.3 Work Area Isolation

As described in the Master Underground Water Management Plan, work area isolation includes “isolating or compartmentalizing those areas to prevent the migration of materials into the water conveyance system.” The master plan suggests work areas may be separated from the remainder of the mine by physical measures such as berms, entrance tunnel modifications, or preplanning of new mine area configurations.

The feasibility of these potential measures was discussed with mine personnel. The challenge to implementing these measures is that they will interfere with mining operations. For example, berms placed between drilling or ore loading areas and water drainage channels will interfere with the passage of vehicles. It is impractical to build the berms up and tear them down every time a vehicle or piece of machinery needs to leave the work area. Entrance tunnel modifications and new mine area pre-planning involve designing tunnels so that a high point exists between work areas and the rest of the mine to prevent the drainage of water impacted by mining activities from leaving the work area. This technique is impractical in most cases because the prevention of mine water drainage from work areas will result in flooding of those work areas. For the reasons discussed above, work area isolation is not considered for further evaluation as a possible water quality control measure for Buick Mine.

3.1.4 Capture of Drill Fines

The Master Underground Water Management Plan also identified the capture of drill fines as a potential control measure. As stated in the Master Underground Water

Management Plan, drilling is conducted for both mine development and ore recovery operations and the drilling process produces fines which have the potential to become suspended in mine water. Three types of drilling are used at Buick Mine:

- Jackhammer drilling is a percussion drilling method used for exploratory drilling in the mine. This is a “wet” drilling technique that generates fine material from the borehole that is carried away from the borehole by water.
- Core drilling is a second exploratory drilling technique that uses water to flush fines away from the core barrel and bit to extract a rock core from the borehole. Drill fines are generated during drilling and carried from the borehole by water.
- Production drilling is a percussion drilling method used during mining operations that can be either air mist or water cooled. Fines are generated in the borehole and carried out of the borehole by water or air.

In general, the quantity of fine materials generated during drilling is relatively small and the water generated during wet drilling is very small relative to other sources of flow in the mine. It is generally infeasible to capture drill fines from any of the above techniques because any method used to capture these fines would substantially interfere with drilling operations. For these reasons, capture of drill fines is not considered for further evaluation as a possible water quality control measure for Buick Mine.

3.2 TREATMENT MEASURES

One type of underground water control measure considered for improving mine water quality is to actually treat the mine water below ground. Treatment processes that may have the potential to improve the quality of mine water include clarification (settling) and filtration.

3.2.1 Clarification

Clarification is a treatment process that involves the removal of suspended solids from water by gravity settling. Simple clarification typically involves the use of basins or sumps that reduce the velocity of flowing water, which allows a portion of suspended solids to settle. Enhanced clarification usually involves the addition of chemicals to facilitate coagulation and flocculation of fine particles that will not settle on their own. These processes are described below:

- Coagulation is the process of adding chemicals to neutralize particle charges that keep particles dispersed. Once the charges of fine particles are neutralized, they will bind together more readily, forming larger particles. This process is often used when very fine particles are suspended.
- Flocculation is the process of providing suitable conditions for fine particles to bind together and often involves very gentle mixing.

Simple clarification is practiced in the Buick Mine, in the form of mine water sumps. These sumps are located throughout the mine and act as settling basins. Simple clarification in the form of mine water sumps will be part of the overall mine water management plan for Buick Mine.

Enhanced clarification using chemicals for coagulation/flocculation, on the other hand, can be a complex process, requiring careful monitoring, with addition of chemicals to adjust the pH of the water being treated for optimization of treatment, followed by readjustment of pH. The process of enhanced clarification results in residuals that are much more difficult to handle and dewater than simple clarification. Providing suitable conditions for settling of the flocculated solids typically requires specialized clarifiers. The challenges of this more complex form of water treatment underground are discussed in Section 3.2.3.

3.2.2 Filtration

Filtration refers to the process of physically separating suspended solids from water by passing the water through material that has openings finer than the suspended materials. This can be accomplished using granular filter materials (e.g., sand filters), woven fabrics, or fabricated plastic or metals filters. The advantage of filtration over clarification is that it results in a more complete separation of water and solids, with the residual solids having lower water content than the residuals of clarification.

Filtration of mine water can potentially be accomplished underground in two ways. First, filters can be used between water sources and water conveyances to remove suspended solids nearer the source. Second, filtration could be used as a centralized treatment process, immediately prior to pumping of mine water to the surface. The use of filtration between water sources and conveyance systems may have potential underground and may be part of the underground water management plan at Buick Mine. Examples of this are the use of sand berms between flowing coreholes and water collection areas, and filter fabric wrapped around perforated HDPE drainage piping along roadways. Centralized filtration of mine water faces similar challenges as other centralized water treatment processes underground, which are discussed in the following section.

3.2.3 Overall Assessment of Underground Mine Water Treatment Feasibility

Mine water treatment processes, such as filtration between water sources, may be feasible treatment practices for mine water underground. Still, further evaluation is needed to determine the impact of these practices on mine water quality and whether or not they are cost effective. Clarification by means of a centralized mine water sump is currently used at Buick Mine and will continue to be a part of the overall water management plan. However, other forms of centralized (i.e., large-scale) underground mine water treatment present several challenges, including:

- Available space – Centralized treatment will require a substantial amount of space in the mine. While space is often readily available at the surface, it must be created in the mine by excavating rock. Areas where mining has already occurred are not good candidates because of the possibility that Doe Run may want to return in the future and extract pillars. New areas are expensive to

create; the estimated cost of excavating rock underground is $0.60 per cubic foot (c.f.). In order to build only a sump, approximately a half million cubic feet of rock would need to be excavated, and that only includes the space needed to contain the water. In addition, because the same equipment and personnel would be used to excavate the area for treatment as would be used for mining, there is a cost in lost ore production.

- Protection of treatment processes – It would be difficult to prevent treatment processes from being exposed to airborne dust in the mine, which could cause additional metals loading to the treatment system or otherwise upset the processes.
- Specialized operators – The types of treatment that would be required to reduce metals in mine water, aside from simple settling, would likely require trained operators. Such personnel are not currently deployed underground by Doe Run and their deployment underground would be more costly than above ground.
- Management of residuals – One of the biggest challenges for underground mine water treatment is the management of residuals. Although settled materials can be managed using conventional construction equipment, materials settled by flocculation have higher water content and would likely require specialized equipment. In addition, because they are flowable, they would require larger areas for disposal (i.e., they cannot be piled).

The use of mine water sumps for clarification (both distributed throughout the mine and at centralized locations prior to pumping to surface) will be part of the underground water management plan for Buick Mine. Other types of centralized underground mine water treatment do not appear to be feasible at Buick Mine because of the challenges outlined above and will not be evaluated further.

3.3 GROUNDWATER INTERCEPTION

Groundwater interception is used here to include all measures that prevent water from entering the mine. Water can enter mine areas in a few ways:

- Coreholes – This refers to exploratory borings advanced from the surface to mine depth or from within the mine into the mine face, used to identify ore locations and direct mining activities. Coreholes sometimes intercept fractures and voids in the rock that convey water and then act as drains to allow water from the rock to enter the mine. To date, this has not been a significant source of water entering Buick Mine.
- Access and vent shafts – These are large-diameter shafts constructed from the surface to mine depth to allow access by personnel and equipment, removal of ore, and ventilation of mine areas. Because they intercept overlying aquifers and penetrate aquitards between the overlying aquifers and the mine, they can become major water sources to the mine. Casing is usually installed in these shafts, which greatly reduces flows. Flows into these shafts can also come

from storm water at the surface, although this contribution is relatively small compared to other flows.

- Fractures – Rock fractures are naturally occurring and mining activities at Buick occur in an aquifer to begin with, so it is common for those mining activities to intersect water-bearing fractures. When this occurs, the fractures become a means of water entry into the mine.

The primary methods available to intercept groundwater before it enters the mine are sealing of coreholes and fractures, casing of shafts, and aquifer dewatering to prevent groundwater from entering coreholes, shafts, and fractures.

3.3.1 Corehole and Fracture Sealing

When mining operations intersect coreholes and fractures, they can become a source of water to the mine. This can be true for a surface corehole if the corehole was incompletely sealed after drilling or if the seal has somehow failed over time. The Doe Run standard operating procedure for exploratory coreholes requires that coreholes penetrating the Davis shale must be fitted with an expandable packer within the bottom part of the formation and the hole must be filled with grout to at least 50 feet above the top of the Davis formation. This standard operating procedure remains in effect.

If a leaking corehole is encountered during mining operations, the corehole can sometimes be sealed using mechanical packers or grout. Mechanical packers have historically been used and have been shown to be effective, although in some cases stopping the flow from a corehole has caused the flow to enter the mine elsewhere. Buick Mine personnel may plug coreholes that yield significant flow when they are encountered during mining, however, this has not been necessary in recent years because most coreholes encountered at the Buick Mine do not have significant flows. In general, mostly at other mines, Doe Run has been evaluating the use of chemical grouts. Two types of chemical grout have been tested at the Fletcher Mine with limited results:

- Two-part grout: This is a two-component grout sold under the trade name H2OSTOP and it has been used for high-inflow coreholes. The grout reacts and sets within seconds of mixing, which is accomplished during injection by a static mixer inside a packer that is inserted in the corehole. The grout can expand in volume up to 20:1 and costs about $195 per cubic foot.

- Moisture-reactive grout: This is a single component grout sold under the trade name Hyperflex that sets in contact with water and is used for lower flow applications. This grout can also expand in volume up to 20:1 and costs about $397 per cubic foot.

These grouts can be effective for sealing fractures as well. Vendor information for both of these products is included in Appendix B. There is no reliable way to estimate how much material will be required to grout a corehole. In the last year, an estimated 200 cubic feet of product has been used. Corehole and fracture sealing will be a part of the underground water management plan for Buick Mine, where it is feasible, technically possible and cost-effective to do so. However, at this time there is not a significant need for this activity because, as stated above, most coreholes encountered at the Buick Mine do not have significant flows.

3.3.2 Shaft Sealing/Repair

Because access and ventilation shafts are necessary for the safe and productive operation of the mine, they cannot be eliminated. Although it is not possible to completely seal the shaft to prevent any water from entering the shaft (and therefore the mine), the standard practices employed by Doe Run are usually capable of eliminating most of the flow. These practices involve the installation of casings in the shafts to seal out water. At present, the shafts at Buick Mine are not a major source of mine water flow. Therefore, shaft sealing/repair is not considered for further evaluation as a possible water quality control measure for Buick Mine.

3.3.3 Aquifer Dewatering

The only other potential flow reduction measure to prevent water from entering the mine is interception of the groundwater in the aquifer before it reaches the mine. This would require installation of dewatering wells at critical points around the mine, at the depth of the contributing aquifers, and pumping of groundwater from the wells. Implementation of aquifer dewatering is a substantial and costly undertaking that would typically only be evaluated for very large sources of flow. Aquifer dewatering would require the following steps:

- Hydrogeological investigation to fully characterize water-bearing units around and above the mine.
- Installation of pumping wells to test the rates at which water could be pumped from the aquifer and the drawdowns in potentiometric surface that could be achieved.
- Evaluation of the ability of pumped groundwater to meet surface water discharge limits.
- Upon completion of the above testing, the dewatering system would be designed and constructed.

One major advantage of this approach is that it involves pumping of groundwater to the surface before it comes into contact with the mine workings. This would presumably eliminate the need for treatment at the surface prior to discharge. It is likely not feasible, however, to use aquifer dewatering for an entire mine, miles in length, due to the costs involved, therefore, aquifer dewatering is not considered for further evaluation as a possible water quality control measure for Buick Mine.

3.4 BEST MANAGEMENT PRACTICES

There are several underground water management practices that can potentially be used to maintain or improve mine water quality. These are referred to as best management practices (BMPs) and several were identified in the Master Underground Water Management plan, including the following:

- Berms
- Channels
- Collection and Containment of Impacted Water
- Clean Mining Areas
- Material Handling and Storage
- Erosion Control
- Roadway Maintenance
- Maintenance Schedules

In addition, sump cleaning and inspections were identified as BMPs that should be considered. These BMPs are discussed below.

3.4.1 Berms

The use of berms was discussed previously in this plan (Section 3.1.3). Because even temporary berms will interfere with the movement of vehicles and equipment in the mine, where working space is already limited, it does not appear that their use is feasible, except in situations where flows can be directed to inactive mining areas, which is already done at Buick Mine.

3.4.2 Channels

Shallow channels are already used throughout Buick Mine to convey mine water flows. As discussed in Section 3.1.2, these channels are already problematic because they expose mine water to more impacts from mine workings. The potential for replacing open channels with enclosed pipes will be discussed in Section 4.

3.4.3 Collection and Containment of Impacted Water

Once water is impacted by exposure to mine workings, it should be isolated from unimpacted water. For example, if impacted water is created at the working mine face during ore extraction operations, it should not be mixed with unimpacted water seeping from coreholes, if this can be avoided.

3.4.4 Clean Mining Areas

In general, maintaining clean mining areas may help reduce the potential for mining activities to impact mine water. This “good housekeeping” practice will be employed to the extent possible in all mining areas and may include storage of ore, drill fines, waste rock, and mining equipment away from areas where water is collected.

3.4.5 Material Handling and Storage

This BMP refers to practices for handling and storage of materials that have the potential to impact mine water quality. This may include stockpiled ore or it may include solids removed from sumps during mucking. The practice for storing such material stockpiles will be that they are placed so as to minimize impacts to mine water.

3.4.6 Erosion Control

As described in the Master Underground Water Management Plan, erosion control in mines includes the protection of any surface that has the potential to erode and increase the loading of suspended solids. These areas include material storage piles and transportation corridors. At Buick Mine, erosion control of storage piles will be addressed by material handling and storage practices and erosion control of transportation corridors will be addressed to the extent feasible by the roadway maintenance program.

3.4.7 Roadway Maintenance

The heavy traffic of trucks and mining equipment over mine roadways, which are normally constructed of crushed rock, can result in erosion of the road surface. This can have two related impacts on mine water quality. First, the erosion of road materials can move fine materials into roadside channels filled with water. Second, the erosion can result in a lowering of the road bed over time, which can eventually lead to flooding of the eroded part of the road. Regular inspection of roadways and prompt repair of eroded areas will be part of the underground water management plan for Buick Mine.

3.4.8 Maintenance Schedules

Scheduling of maintenance activities related to underground water management at Buick Mine will be driven by monitoring and inspection activities, as discussed in Section 4.

3.4.9 Sump Cleaning

At Buick Mine, like all Doe Run mines, mine water flows via gravity and/or pumping to central sumps where it is then pumped to the surface. At Buick Mine, one main mine water sump is currently used.

All mine water sumps provide temporary storage for mine water and, as a result, can have potential for settling solids, proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids, by design. This means, however, that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, accumulated solids could eventually impair pumping. For these reasons, periodic maintenance of the sumps is required to remove solids. The process of sump cleaning is referred to as “sump mucking”.

Sump mucking involves temporarily draining the sump, then mechanically removing the accumulated solids from the sump. The solids are transported to an inactive area of the mine for storage, where they dewater by gravity drainage. Since they consist of fine rock and ore, the dewatered solids are sometimes added to the mined materials sent to the surface for processing.

Experience at Doe Run mines shows that sump cleaning results in excessive wear on the machinery that is used to remove the accumulated solids because the fine solids get into the mechanical and hydraulic components of the machinery and are abrasive. Significant costs can be incurred for equipment refurbishment after every sump mucking event. Because sump cleaning is a necessary component of mine operations, it will be continued in the future and is discussed further in Section 4.

3.4.10 Inspections

Regular inspection of mine water management measures will be an important part of the overall underground water management plan at Buick Mine. These inspections will be used to monitor effectiveness of the plan and to identify the need for maintenance of roadways, piping, sumps, and other mine water management measures.

3.5 SUMMARY OF WATER MANAGEMENT MEASURE EVALUATION

Several potential water management measures have been identified for the Buick Mine as they may have the potential to reduce mine water flows and improve water quality. The measures are summarized in Table 3-1 along with notation on which will be part of the Buick underground water management plan. In all cases, the use of the measures discussed here will be evaluated and implemented if Doe Run determines that the measures are effective, technically feasible, and cost effective, or will be further evaluated for potential implementation.

Table 3-1. Summary of Water Management Measure Evaluation for the Buick Mine.

Type of Measure	Measure	Assessment Summary	Included in Buick UGWMP?
Isolation	Piping	Potentially effective on a localized basis; to be evaluated further	Yes
	Channel lining	Not an effective control measure	No
	Work area isolation	Not feasible	No
	Capture of drill fines	Not feasible	No
Treatment	Clarification	Simple settling feasible; enhanced clarification infeasible	Yes
	Filtration	Potentially feasible on a localized basis; will undergo further evaluation	No
Groundwater Interception	Corehole/fracture sealing	Not currently needed; will be considered on an as-needed basis in the future	No
	Shaft repair/sealing	Not needed	No
	Aquifer dewatering	Not part of plan, pending outcome of investigations at Sweetwater Mine	No
Best management practices (all to undergo regular review and evaluation)	Berms	Useful in some case	Yes
	Channels	Necessary, piping preferred in some areas	Yes
	Collection/ containment	Potentially useful	Yes
	Clean mining areas	Potentially useful	Yes
	Material handling/storage	Potentially useful	Yes
	Erosion control	Addressed by material handling & roadway maintenance	No
	Roadway maintenance	Potentially useful	Yes
	Maintenance schedules	Necessary, driven by monitoring and inspections	Yes
	Sump cleaning	Necessary	Yes
	Inspections	Necessary	Yes

This page is blank to facilitate double sided printing.

4. PLAN ELEMENTS AND IMPLEMENTATION

The underground water management plan for Buick Mine is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of potential measures focusing on cost-effectiveness and impact on water quality;
- Development of planned actions;
- Implementation of planned actions;
- Monitoring of implemented actions (data collection and inspection);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Buick Mine plan discussed in this section are:

- Water management actions
- Best management practices
- Monitoring
- Inspection
- Recordkeeping
- Training
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections. It should be noted that mine water treatment evaluations are ongoing at Doe Run. The outcome of these evaluations will determine the most effective mine water treatment method, as well as an accurate estimate of the unit cost for mine water treatment. This will allow evaluation of potential underground water control measures in the context of relative cost-effectiveness, compared to treatment at the surface. Based on these comparisons, some of the measures discussed in this section may be determined not to be cost effective and may be removed from the plan in the future.

4.1 WATER MANAGEMENT ACTIONS

Based on the review of mine data discussed in Section 2 and the evaluation of potential control measures discussed in Section 3, existing practices, procedures, and planned projects are generally appropriate for underground water management at

Buick Mine. In addition, two contingency plans will be set up for the Buick Mine to address future potential opportunities for water management actions: corehole sealing contingency and piping contingency. These are described below.

4.1.1 Casteel V10 Mine Water Sump

As discussed in Section 2.1.1 of this plan, construction of a new mine water sump in the north part of Casteel Mine is completed. This sump, called the V10 sump, increased the mine water pumping capacity at Casteel by 3,000 gpm. The additional mine water handling capacity in Casteel mine resulting from this project eliminated the need to transfer mine water from Casteel to Buick. Therefore, the mine water previously pumped to the Buick mine is now diverted to the Casteel Lower Main Sump. This has reduced average mine water flows from Buick mine by about 1,000 gpm. The V10 project was completed by January 2012.

4.1.2 Corehole Sealing Contingency Program

Although coreholes are not currently a significant source of influent mine water at Buick Mine, there is the possibility that coreholes will be encountered in the future that yield higher flows. For this reason, a corehole sealing contingency program will be implemented. This contingency program will include a standard operating procedure and decision framework for determining which coreholes will be sealed. New coreholes that are encountered during mining operations and that produce significant flows to the mine may be sealed, if sealing is technically possible and cost-effective. If possible, the following procedure will be followed:

- Flowrate from the corehole will be estimated by measuring the time required to fill a 55-gallon drum or other similarly-sized container of known volume. If it is not possible to measure the flowrate from the corehole in this manner due to the location of the corehole and difficulty in positioning the container under the stream of flow, a 5-gallon bucket or similar smaller container shall be used. If this is also impractical due to the very small quantity of flow or for safety reasons, the underground water management team will discuss alternate flow estimation methods. Because flows from newly encountered coreholes sometimes vary, the flow will be measured once a month for three months.
- The diameter of the corehole will be measured to the nearest inch. If it is impossible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.
- After measuring the flow and the corehole diameter, the underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past. If the underground water management team is not certain whether sealing is feasible, they will consult with manufacturer’s representatives for mechanical plugs and grouts to help determine the feasibility of sealing the corehole.
- If it is determined that the corehole can be sealed, the underground water management team will determine a schedule for sealing that takes into

account the priority of the action relative to other water management measures.

The above process is documented in the form of a standard operating procedure, included in Appendix C. Corehole sealing will be documented in writing. The methods and procedures used for sealing will be documented, along with problems encountered and apparent success of the sealing, for future reference.

4.1.3 Piping Contingency Program

No piping projects are currently planned for the Buick Mine for the sole purpose of addressing water quality. However, future circumstances may warrant consideration of piping to address water quality, so a contingency program for piping will be maintained as part of this plan.

Data collected at Doe Run mines indicate that the quality of mine water entering mines can be degraded within a short distance of the point of entry. Therefore, before piping to maintain water quality, the underground water management team will continue to determine whether the piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation. This will likely be accomplished by containing the water at the point of entry with a sump or other system and piping directly from the sump to a main mine water sump.

If the source of the incoming water is a corehole, the procedures outlined in Section 4.1.1 will be followed before piping is evaluated. If the source of the water is a corehole that cannot be sealed, the underground water management team will use the following protocol to determine whether piping will be installed:

- The physical setting and surroundings of the source will be assessed by the underground water management team to identify options for containing the incoming flow as close to its source as possible. This process will consider quantity of flow, space availability, accessibility of the source, other mine operations, cost, and safety.
- Once the most feasible and cost-effective option for containing the flow is determined, the underground water management team will determine the flow path the water will follow to reach the containment area. Water samples will then be collected at the end of that flow path, at the point where water would enter the containment area, as well as the point of entry to the mine (i.e., the corehole, fracture, or shaft). This water sampling will follow the standard procedures for sampling that are currently in place for water sample collection.
- The sampling results will be compared to the results for the incoming water as a measure of the water quality degradation that will occur along the flow path to the location of the containment. The results will also be compared to water quality data from the mine water sump to which the water would be piped. The underground water management team will use these comparisons

to determine whether the piping is likely to provide a significant water quality benefit and whether the piping is cost-effective.

All data collected during piping evaluations will be recorded. Upon review of new data in the future, if a piping project is determined to be ineffective, the piping project may be terminated or, if already installed, the piping may be removed for use elsewhere.

4.1.4 Ongoing Water Management Measure Evaluations

In addition to the corehole sealing and piping contingency programs described above, the following additional actions will be considered on an as-needed basis:

- Additional piping – As mine expansion occurs, significant inflows of relatively clean groundwater may be encountered and, in some cases, it may be feasible and cost-effective to contain the water locally and pipe it directly to mine water sumps. This measure will be evaluated by the water management team on a case-by-case basis.
- New corehole sealing techniques/materials – The water management team will continue to evaluate new techniques or materials for corehole sealing, as they become available.
- New mine water pump shafts – As mining operations progress, it may become feasible to construct new pump shafts to the surface, as an alternative to moving water from newly mined areas to existing mine water sumps. This will be evaluated by the water management team on an as-needed basis.
- Mine expansion – During mine expansion activities, mine personnel will consider water management strategies from a water quality, as well as logistical, perspective and identify environmentally-appropriate water management strategies into the expansion design.

As with the planned activities described in the preceding section, control measure evaluations will be documented in future updates to this plan.

In addition to the contingency actions outlined above, best management practices, as described in Section 4.2, will be used to manage water quality.

4.2 BEST MANAGEMENT PRACTICES

Several BMPs will be implemented at Buick Mine as part of this plan, as described in the following sections. Some of these BMPs, such as berms, channels, collection, and clean mining areas will likely be used relatively infrequently because of their limited applicability. Others, such as roadway maintenance and sump cleaning will be performed more frequently, but still on an as-needed basis. BMPs and the conditions where they may be useful will be discussed during personnel training.

4.2.1 Berms

Berms are low barriers used to direct flowing water in a desired direction, away from its natural course. Although the use of berms to contain water within work areas is infeasible due to interference with mining activities, as described in Section 3.1.3, berms may be useful in areas of the mine where active mining and hauling is not occurring. Berms may be considered a potential water management practice in areas where they will not interfere with mining.

4.2.2 Channels

Channels are shallow watercourses, usually along roadways, in the mine. Although allowing water to flow uncovered in channels has been identified as a source of water quality degradation, there may be situations where construction of channels will be useful. For example, as with berms described above, channels may be useful in diverting flow away from main mine water sumps towards unused or inactive areas of the mine. In such situations, a simple open channel might be used or a combination of channel and pipe may be used, where the diverted flow has to cross a roadway.

4.2.3 Collection/Containment

Collection or containment may be used, where feasible and cost-effective, in situations where water impacted by mining activities is in proximity to sources of relatively unimpacted water. Possible collection/containment techniques may include:

- Construction of a local sump to collect the impacted mine water or the unimpacted water source for pumping.
- Use of diversion channels or berms to direct the flow of impacted mine water away from the source of unimpacted water.

The appropriate method of collection or containment will be determined on a case-by-case basis. In situations where the unimpacted water source is a newly discovered corehole, the procedure for evaluating corehole sealing will be followed.

4.2.4 Clean Mining Areas/Material Handling and Storage

The ‘Clean Mining Areas’ and ‘Material Handling and Storage’ BMPs discussed in Sections 3.4.4 and 3.4.5 are combined here because they are closely related. This combined BMP refers to maintaining work areas in the vicinity of open mine water in such a way as to minimize the potential for water quality degradation. This is especially relevant to areas around sumps and around channels that have not been piped. Where possible, stockpiled materials such as ore and waste rock should be located to minimize impacts to water. Equipment should also be stored away from water where possible.

4.2.5 Roadway Maintenance

Roadways will be inspected on a regular basis by mine supervision personnel and any significant repairs will be documented. These inspections will be specifically directed at identifying roadway conditions that might contribute to water quality degradation including, but not necessarily limited to, the following:

- eroded sections of the roadway that are likely to contribute to the degradation of mine water quality (repaired by filling to an acceptable grade)

- broken or plugged drain pipes (repaired by replacing broken pipe or clearing plug)
- water entering from the back and falling onto the road causing erosion (repaired by suspended curtains of suitable material over the roadway to divert falling water to ditches)

It should be noted that there may be cases where a low point in a roadway exists because it is the low point of the mine tunnel and not necessarily due to erosion. In such cases, filling may create insufficient clearance between passing trucks and the back, so repair is not feasible. When appropriate, significant problems and repairs will be logged in the Doe Run Enterprise Task Management System (ETMS).

4.2.6 Maintenance Schedules

Maintenance related to underground water management at Buick Mine will be performed on an as-needed basis. Regularly scheduled inspections may identify additional maintenance needs.

4.2.7 Sump Cleaning

The main mine water sump will be inspected quarterly as part of the routine water management inspection program at Buick Mine. Part of this inspection will be reading of depth soundings to monitor the level of accumulated solids in the sump. If it is logistically possible, the main mine water sump at Buick Mine will be equipped with a sonar depth finder capable of measuring the depth to the sediment/water interface. If this equipment can be installed, initially, a decrease in water depth of 50% at a point in close proximity to the pumps will be used to trigger sump cleanout. This level of fill is based on the experience of mine personnel. As described below, the main mine water sump will be sampled on a regular basis and these data will be evaluated along with the level of accumulated sediment to determine whether a different level should be used to trigger sump cleaning. A standard operating procedure for monitoring sediment levels in main mine water sumps is included in Appendix C.

4.3 MONITORING

Ongoing underground water quality monitoring will be continued at the Buick Mine to improve the understanding of mine water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 4-1 will be sampled, unless it is determined by Doe Run that an adequate amount of data has been collected.

Table 4-1. Underground Water Sampling Locations for the Buick Mine.

Location	Sample ID Previously Used	Rationale
Main mine water sump	BU-1-5MNSPINF	Monitor water quality in sump
Mine water ditch immediately south of main sump	BU-15SDitch	Monitor water quality entering main sump from south part of mine
Mine water pipe leading from north dam	BU-1-5NDam	Monitor water quality entering main sump from north
Magmont mine water sump	BU-MAGSHAFTSUMP	Verify water quality in Magmont sump (combined Magmont & Casteel); assess change after Casteel flow eliminated
Mine water from Magmont drift	BU-MAGWC-Level	Monitor mine water quality from Magmont
Mine water from A6 development*	BU-A6DEV	Monitor mine water quality from A6 development
*The actual sampling location will be determined in conjunction with mine personnel, in consideration of future mine development plans.		

Continued monitoring was initiated in March 2012, and has typically been conducted on a monthly basis. The results of the continued monitoring efforts are presented in Figures 4-1 through 4-5. Evaluation of the most recent data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

In addition to the monitoring regime described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for underground water management at Buick Mine.

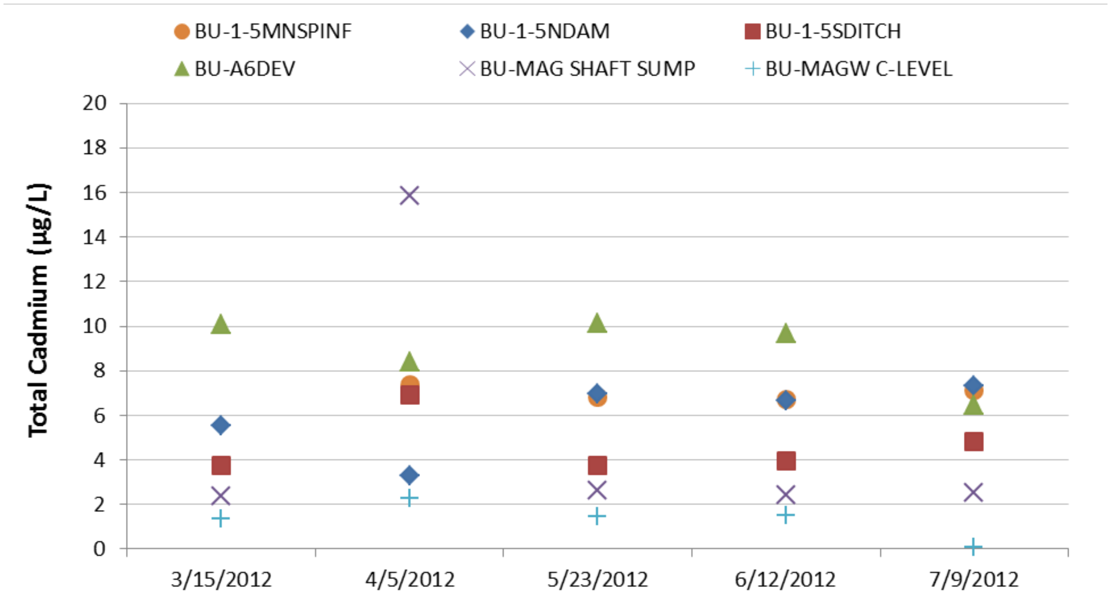


Figure 4-1. Continued Monitoring of Total Cadmium in Underground Sampling Locations at Buick Mine.

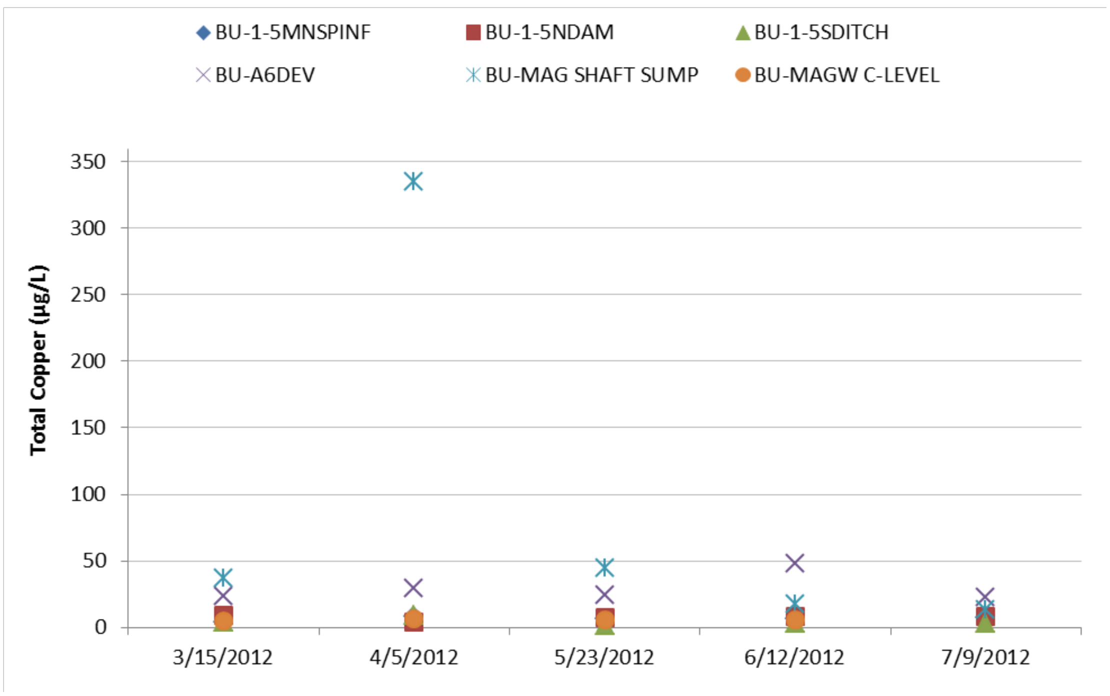


Figure 4-2. Continued Monitoring of Total Copper in Underground Sampling Locations at Buick Mine.

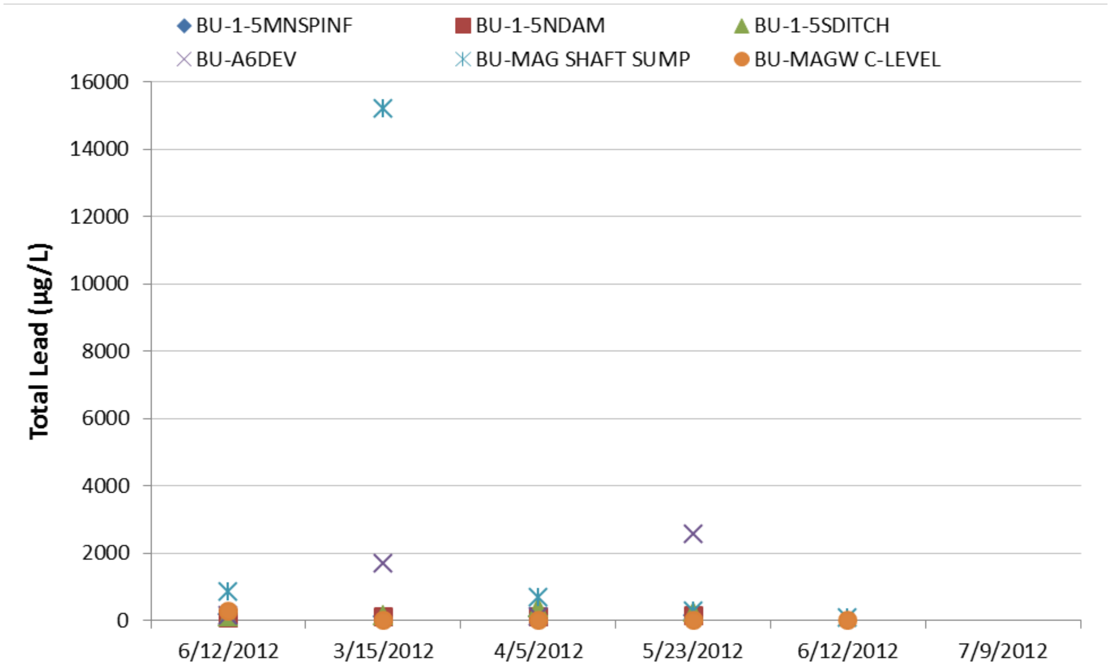


Figure 4-3. Continued Monitoring of Total Lead in Underground Sampling Locations at Buick Mine.

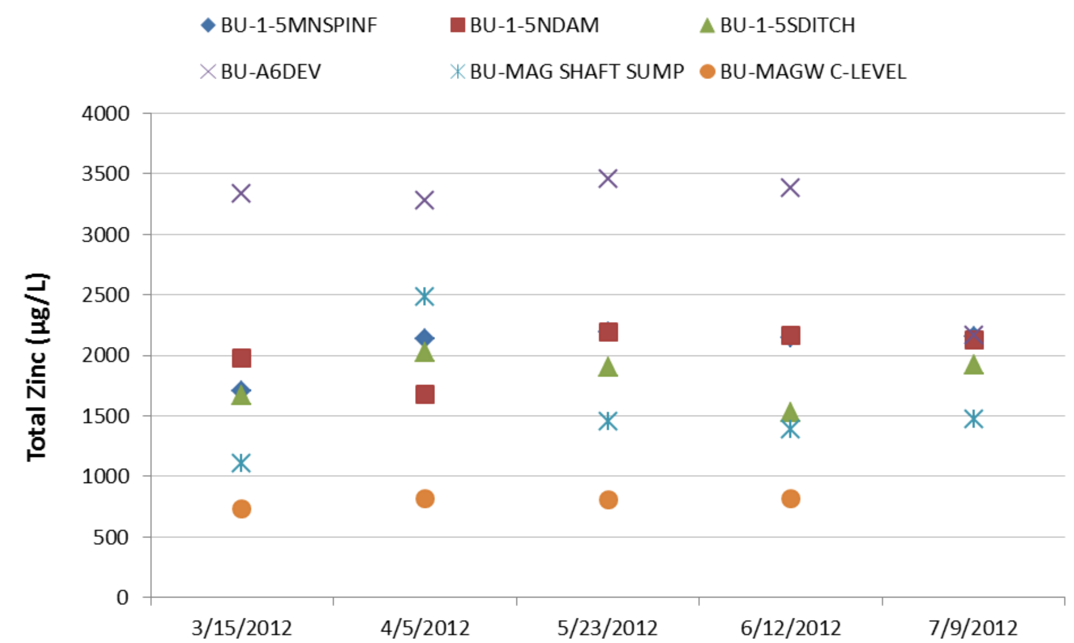


Figure 4-4. Continued Monitoring of Total Zinc in Underground Sampling Locations at Buick Mine.

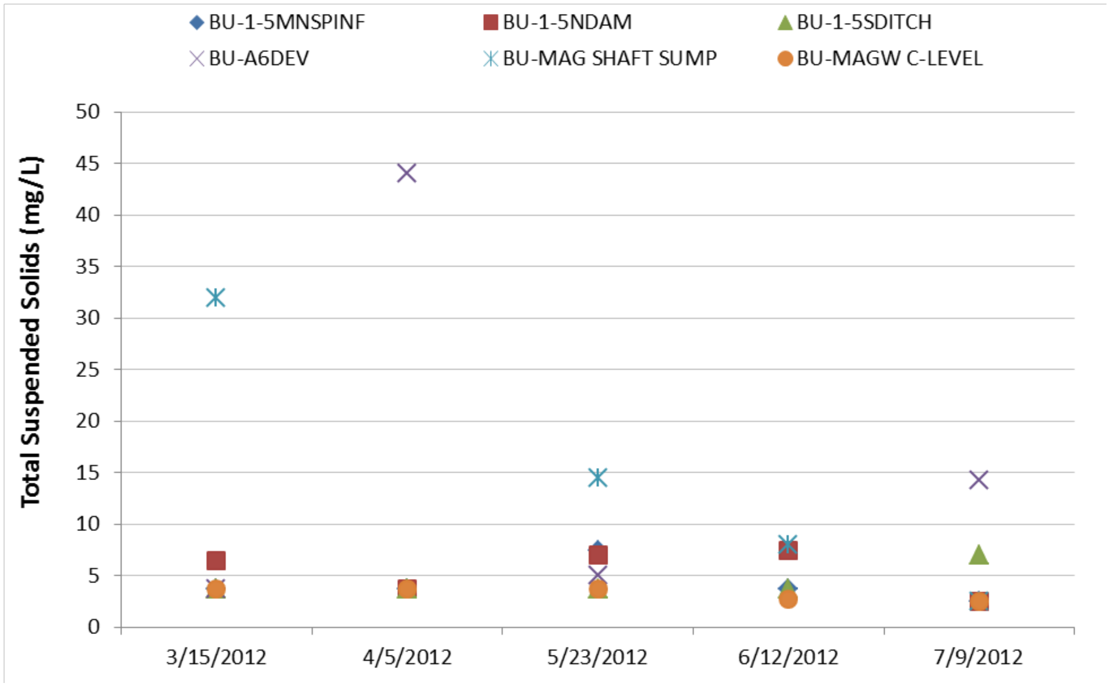


Figure 4-5. Continued Monitoring of Total Suspended Solids in Underground Sampling Locations at Buick Mine.

4.4 INSPECTIONS

Underground water management inspections will be conducted at Buick Mine on a quarterly basis to monitor effectiveness of water management measures and to identify the need for maintenance. Inspections will include visual inspection of the following:

- Main mine water sump to visually assess turbidity and general condition;
- Water piping, to identify leaks;
- Roadways, to identify the need for maintenance;
- Material and equipment storage areas to identify the need for improved separation from sources, conveyances, and sumps;
- Coreholes and/or fractures scheduled for sealing between the previous and current inspections, if any, to verify that sealing has occurred and was effective;
- Sources of water identified since the previous inspection; and
- Any other water management actions undertaken since the last inspection.

Inspections will be conducted by trained personnel (see Section 4.5). All inspections will be documented using the form in Appendix D, which will include the name and signature of the person performing the inspection.

4.5 TRAINING

Training was identified in the Master Underground Water Management Plan and will be an important part of the plan for Buick Mine. Initial training will be provided by April 30, 2012 to all personnel involved in the management of water at Buick Mine including, but not necessarily limited to:

- Mine supervision
- Mine engineers
- Technical service personnel
- Environmental technicians

In addition to the initial training for these personnel, annual refresher training will be conducted.

The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for underground water management (including the environmental need);
- Best management practices to be used throughout the mine;
- Specific water management actions being implemented or planned;
- Water management protocols and standard operating procedures;
- Inspections;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

4.6 TRACKING/RECORD-KEEPING

Water management measures will be inspected at Buick Mine quarterly and the inspections will be documented on the form included in Appendix D. These forms will be kept on file on-site by the Buick Underground Water Manager, Jeff Gibson or designee. In addition, all significant water management measures and best management practices implemented at Buick Mine will be documented in writing and a copy kept on file at the same location. Actions taken, best management practices, inspections, and maintenance of underground water management measures will be recorded in the Doe Run ETMS.

4.7 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between December 1, 2012 and January 31, 2013. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Buick Mine facility.

4.8 IMPLEMENTATION SCHEDULE

The current schedule for the water management plan implementation is presented in Table 4-2. This schedule is based on the best information available as of the date of this plan.

Table 4-2. Implementation Schedule for First Year Underground Water Management Plan Activities at Buick Mine.

Action	Feb. 2012	Mar. 2012	April 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Apr. 2013	Dec. 2013
Training														
Inspections	Once per Calendar Quarter													
Sampling							As needed							
Plan Review & Update														

5. REFERENCES

LimnoTech. Underground Water Sampling and Analysis Plan Report. August 4, 2011. (LimnoTech, 2011)

Resource Environmental Management Consultants, Inc. *Master Underground Water Management Plan: The Doe Run Company SEMO Operations*. 2010. (RMC, 2010)

U.S. Geological Survey. "History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict" (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008)

This page is blank to facilitate double sided printing.

APPENDIX A:

BUICK MINE WATER FLOW MAP WITH LEAD AND ZINC SAMPLING RESULTS

This page is blank to facilitate double sided printing.


BUICK
WATER SAMPLING DATA
2-15 & 21-11, 3-23-11, 6-7-11
Final Effluent Limits
Total Pb - 13.0 ppb
Total Zn - 177 ppb
TSS - 20 ppm
(all results listed in units above)
BUICK MINE
Water Schematic
Scale 1" = 500'
August 2011
LEGEND
Flygt 2102: 8.2HP
24 Ditch
BU-35WBoundry
TPb DPb TZn DZn TSS
2-15-11 225 43.2 298 233 6.0
3-23-11 408 51.1 442 418 0
6-7-11 406 32 353 211 11
BU-MAGWC-Level
TPb DPb TZn DZn TSS
2-15-11 18.7 9.1 852 738 0
3-23-11 18.6 9.9 872 946 0
6-7-11 19 6 1049 796 6
BU-MAG Shaft Sump
TPb DPb TZn DZn TSS
2-15-11 231 38.1 1230 1190 6.0
3-23-11 412 42.4 1460 1330 13.0
6-7-11 103204 1 1610 809 10
Magmont Shaft Pump
Pioneer
BU-A10
TPb DPb TZn DZn TSS
2-15-11 28.6 2.3 3960 3630 5.0
3-23-11 43.3 3.9 3960 4250 0
6-7-11 33 1.4 4309 3633 2
6-7Dup 40 1.2 4244 3567 1
A6 Dev
1-4 Level 10200 ft
1-4 Level 10200 ft, 1100 GPM
1-4 Level 540 ft, 100 GPM
C-Level 570 ft
1-4 Level 60 ft
1-4 Level 180 ft
1-5 Level 1600 ft
1-4 Level 380 ft
BU-CR2Thompson
TPb DPb TZn DZn TSS
2-15-11 85.3 69.4 7620 6780 0
3-23-11 146 64.8 7280 7150 0
6-7-11 74 46 7260 6666 3
130 North Pump
Flygt Model 2201: 58HP
3500 GPM capacity
130 North Pump
Flygt Model 2250: 87HP
4700 GPM capacity
BU-WUC
TPb DPb TZn DZn TSS
2-15-11 44.0 1.9 2420 2180 0
3-23-11 41.8 1.7 2780 2810 0
6-7-11 52 3 2813 2254 1
1-5 Level 3000 ft
6" Pipe ~1000'
12" Pipe ~1000'
BU-125NDIS
TPb DPb TZn DZn TSS
2-15-11 137 62.4 1720 1590 0
3-23-11 123 64.8 1620 1710 0
6-7-11 257 40 1995 1610 6
BU-WUCPipe
TPb DPb TZn DZn TSS
2-15-11 5420 10.7 16300 12000 195
3-23-11 4980 64.1 5080 4430 214
6-7-11 453 .46 4678 3080 fa
BU 113N1-5Level
BU-WinSDevCoreH
TPb DPb TZn DZn TSS
2-15-11 6.2 5.3 809 846 0
3-23-11 26.5 6.6 548 582 0
6-7-11 33 .07 1436 847 5
1-5 Level 7900 ft
1-5 Level 1800 ft
1-5 Level 1200 ft
3 1-5 Level Pumps
Peerless 14LC, 500HP
1000 GPM capacity
500 GPM to Surface
BU-1-5NDam
TPb DPb TZn DZn TSS
2-21-11 133 23.1 2010 1850 0
3-23-11 82.2 10.4 2220 2200 0
6-7-11 45 1.3 2004 1552 1.5
BU-1-5Main Sump INF
TPb DPb TZn DZn TSS
2-21-11 365 32.5 1710 1200 19.0
3-23-11 150 29.7 1990 1920 0
6-7-11 2442 44 2376 1635 35
1-5 North to Sump 330 ft, 3000 GPM
1-5 Level to Main Sump 500 GPM
BU-1-5SDitch
TPb DPb TZn DZn TSS
2-21-11 128 69.9 1490 1550 5.0
3-23-11 177 95.4 1480 1540 0
6-7-11 4221 51 2514 1649 48
BU-1-5Main Sump
TPb DPb TZn DZn TSS
2-21-11 7090 52.0 2730 1650 23
1-4 Level 180 ft
6 Main Sump Pumps
Fairbanks Morse, 350HP
870 GPM capacity,
3500 GPM to Surface
1-4 Level 260 ft
80 South Pump
Flygt Model 2102: 8HP
600 GPM capacity
1-5 Level 8600 ft
BU-106SDWSUMP
TPb DPb TZn DZn TSS
2-15-11 993 61.9 1540 1520 12
3-23-11 414 79.6 1190 1250 5
6-7-11 179 44 1378 1103 4
BU-A11 Discharge
TPb DPb TZn DZn TSS
2-15-11 705 60.3 333 260 0
3-23-11 270 66.2 348 315 0
6-7-11 209 36 270 172 1.5
A7 DRILL WATER PUMP AREA
BU-A11 DWSump INF
TPb DPb TZn DZn TSS
2-15-11 181 57.7 48.3 40.3 0
3-23-11 96.4 59.3 51.9 63.6 0
6-7-11 39 16 26 23 0
Area 7 U/C Pump
Flygt Model 2102: 8HP
600 GPM capacity per pump
BU-7UC Effluent
TPb DPb TZn DZn TSS
2-15-11 361 60.1 908 909 0
3-23-11 152 68.8 791 831 5.0
6-7-11 265 38 919 673 5
Area 7 U/C Pump
Flygt Model 2125: 13HP
300 GPM capacity per pump
BU-A11NE CH
TPb DPb TZn DZn TSS
2-15-11 0 1.1 0 23.8 0
1-5 Level 920 ft
1-5 Level 850 ft
1-5 Level 1600 ft
1-4 Level 270 ft
1-4 Level 1200 ft
1-5 Level 1000 ft
1-5 Level 1600 ft
BU-14DV Effluent
TPb DPb TZn DZn TSS
2-15-11 90.4 52.8 4510 2680 0
3-23-11 107 62.4 2590 2680 0
6-7-11 80 47 3344 2837 0
Area 14 Pump
Flygt Model 2151: 30HP
1500 GPM capacity
BU-A11NEDVRibCH
TPb DPb TZn DZn TSS
2-15-11 0.92 1.7 0 6.2 0
BU-180 SDWSUMP
TPb DPb TZn DZn TSS
2-21-11 257 54.8 306 281 0
3-23-11 179 57 468 525 0
6-7-11 118 37 332 235 0
1-5 Level 4000 ft
1-4 Level 2200 ft
BU-WBCDoor
TPb DPb TZn DZn TSS
2-15-11 3190 52.0 704 373 57.0
3-23-11 1110 61.8 866 795 13.0
6-7-11 895 42 294 154 7
BU-A11South CH
TPb DPb TZn DZn TSS
2-15-11 0.43 0.76 0 7.4 0
BU-EBCDoor
TPb DPb TZn DZn TSS
3-23-11 313 53.2 513 503 0
6-7-11 68 34 352 251 0
BU BCR
BU A11 Core D

APPENDIX B:

VENDOR INFORMATION ON GROUT USED FOR COREHOLE SEALING

This page is blank to facilitate double sided printing.

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

HYPERFLEX

Single component, low density, flexible, hydrophobic grout.

Uses

Sealing of water and gasses in mining and civil applications. Reacts with moisture to form a flexible closed cell grout.

Advantages

- **Simple application**
- **Adjustable set time with catalyst**
- **Flexible, absorbs movement**
- **Low expansive pressure**
- **"Self injection" into the finest of fractures**

Packaging

55 Gallon Steel Drums
5 Gallon Plastic Containers
5 Gallon Metal Containers
1 Gallon Metal Containers

Approvals

NSF 61-2007 approved for use with potable water.

Transport

USDOT. Unregulated Class 55

Physical Properties

Density	Free rise	2.25 lbs/ft³
Low temp. aging	Confirmed	
-20° F (shrinkage)	0% 1 Day	ASTM D-2126
Viscosity	4000 cps	ASTM D-2126
Specific Gravity @ 60° F	1-30%	A-Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Compressive	25 psi	ASTM D-1621
Shear	171 psi	ASTM C-273
Tensile	30 psi	ASTM D-1623
Elongation	300%	ASTM D-1623

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture.

Shelf Life

2 year minimum in unopened containers.

Caution: Always read MSDS prior to use.

WWW.Sub-Technichal.com

724 625 0008 VOICE 724 625 0009 Fax

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

STI 03 - 0.03

H20STOP

Dual component, low density, highly reactive, early strength, water control grout

Uses

Water control in mining and civil applications for cessations of high (3,000 G.P.M. +) leaks, combined with rapid void filling and early strength characteristics.

Advantages

- **Extremely fast reacting**
- **Rapid sealing**
- **High early strength**
- **Will inject into the finest of fractures**
- **Will not wash out**

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture. Store under 80 degrees.

Packaging

55 Gallon Steel Drums

Approvals – On file

Transport

USDOT Unregulated Class 55

Shelf Life

2 Year minimum in unopened containers.

Physical Properties

-20º F (shrinkage)	0% 1 day	ASTM D-2126
Viscosity @ 68º F	200 cps A – Side	300 cps B – Side
Specific Gravity @ 60º F	1.23 A - Side	1.04 B - Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Density (Free Rise)	03 PCF	ASTM D-1622
Compressive	200 psi	ASTM D-1621
Tensile	112 psi	ASTM D-638
Shear	107 psi	ASTM D-732

Sub-Technical, Inc.
363 Mars Valencia Road
Mars, Pennsylvania 16046 U.S.A.
Phone: (724)625-0008 Fax: (724)625-0009
www.sub-technical.com
stisales@sub-technical.com

Always Read MSDS Sheets Prior to USE

APPENDIX C:

STANDARD OPERATING PROCEDURES

This page is blank to facilitate double sided printing.

I. INTRODUCTION

Exploration coreholes at the Doe Run Mines are currently sealed by mine personnel. This practice has been in place for many years. New coreholes that are encountered during mining operations and that produce significant flows to the mine will be sealed, if sealing is technically feasible. This standard operating procedure provides a decision framework and guidelines for monitoring and sealing coreholes when they are encountered during mining operations.

II. MATERIALS

The following materials, as required, will be used when coreholes are encountered:

- Any necessary safety equipment;
- 55 gallon drum or other similarly sized container of known volume;
- 5 gallon bucket or similar smaller container;
- Stopwatch;
- Measuring tape;
- Field log;
- Mine map;
- Camera.

III. PROCEDURES / GUIDELINES

When a corehole is encountered during mining operations the following procedures shall be used:

A. Determine flow rate from corehole

1) Flowrate from the corehole will be estimated by measuring the time required to fill a 55 gallon drum or other similarly sized container of known volume.
2) If the location of the corehole prevents the use of a 55 gallon drum or if the flow is too small for filling of a 55-gallon drum to be practical, then a 5 gallon bucket or similar smaller container will be used.
3) If, due to the quantity of flow or for safety reasons, it is not possible to measure the flow, this should be reported to the underground water management team who will determine an alternate flow estimation method.
4) Because flows often change after coreholes are encountered, the flow rate will be measured once per month for three months to obtain a better estimate of its long-term flow.

B. Measure the corehole diameter

1) The diameter of the corehole will be measured to the nearest inch.
2) If it is infeasible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.

C. Determine if sealing is required and feasible

1) If the flow from the corehole exceeds 25 gallons per minute the corehole will be sealed.
2) The underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past.
3) If it is unclear whether sealing is feasible, the underground water management team will consult with manufacturer's representatives for mechanical plugs and grouts to help

determine the feasibility of sealing the corehole.

D. Seal the corehole

If it has been determined that the corehole can be sealed, the underground water management team will determine a schedule for the sealing work and ensure that the work is completed.

E. Documentation

The following information must be recorded in writing and submitted to the underground water manager:

1) Corehole discovery time and date.
2) Location of corehole recorded on map
3) Diameter of corehole
4) Measured flowrate – record procedure and results
5) Determination of sealing requirement
6) Problems encountered with sealing determination
7) Communication with the underground water management team
8) If the corehole cannot be sealed – record the reasons for that determination
9) Methods and procedures of corehole sealing
10) Problems encountered in the sealing process and apparent success
11) Sealing completion time and date.
12) Pictures of the corehole will also be taken and kept with the field log.

I. INTRODUCTION

Mine water sumps provide temporary storage for mine water, which results in the settling of solids proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids. This means that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, the accumulated solids could eventually impede pumping. For these reasons, periodic maintenance of the sumps is required to remove accumulated solids.

The process of sump cleaning is referred to as "sump mucking". This involves draining the sump, then mechanically removing the accumulated solids from the sump. This standard operating procedure provides guidelines for monitoring main mine water sumps and determining the need for sump cleanout.

II. MATERIALS

The following materials will be available to monitor mine sumps:

- Personal protective equipment as required by the Health and Safety Plan;
- Light source;
- Depth finding device;
- Tape measure;
- Field log;

III. PROCEDURES / GUIDELINES

All major mine sumps will be cleaned when the accumulated solids exceed 50% of the water depth in the sump at the point of measurement near the pumps. To determine the sump mucking trigger, the following procedures must be adhered to:

A. Depth Measurement

1) A depth finding sonar device will be installed near the pumps at each of the major mine sumps to measure the depth of sediment in the sump.
2) A standard reference mark will be established for each sump, to which the water level can be referenced on a recurring basis.
3) The water level will be determined by measuring from the standard reference mark down to the water level with a tape measure.
4) As an alternative to steps 2 and 3, mine personnel may opt to install a staff gauge in the sump for measuring water level.

B. Inspection

1) During each quarterly inspection, the water level and depth to solids in each sump will be recorded from depth finding device.

C. Documentation

The following information will be recorded:

1) Sump identification/location
2) Sump inspection date
3) Measurement of water level
4) Measurement of depth to sediment in each sump
5) Notification of underground water management team, if the depth of solids is more than 50% of the water depth in the sump
6) Start and end date for sump cleanout and problems encountered

APPENDIX D:

UNDERGROUND WATER CONTROL MEASURE INSPECTION FORM

This page is blank to facilitate double sided printing.

Underground Water Management Inspection

Date: ________________________ **Inspection By:**_________________________

Mine: ____

Notes: ____

Sumps

Sump ID/Location	Water Level	Depth to Sediment	Notification Date

Notes: ____

____

____

Piping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

Underground Water Management Inspection

Date: ______________________ **Inspection By:**______________________

Roadways

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

BMPs/General Housekeeping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

EXHIBIT M

UNDERGROUND WATER MANAGEMENT PLAN for the BRUSHY CREEK MINE

Prepared for: **The Doe Run Resources Corporation d/b/a The Doe Run Company**

March 1, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix A: Brushy Creek Mine Water Flow Map with Lead and Zinc Sampling Results
Appendix B: Vendor Information on Grout Used for Corehole Sealing
Appendix C: Standard Operating Procedures
Appendix D: Underground Water Control Measure Inspection Form

1. INTRODUCTION

This document presents the Underground Water Management Plan (UGWMP) for the Brushy Creek Mine, prepared on behalf of the Doe Run Resources Corporation, d/b/a/ The Doe Run Company (DRC). The Brushy Creek UGWMP has been prepared in accordance with the Master UGWMP previously prepared by Resource Environmental Management Consultants, Inc. In keeping with the Master UGWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Brushy Creek Mine is located in Iron and Reynolds Counties, Missouri, approximately 7 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Brushy Creek Mine (USGS, 2008).

Year	Event
1968	St. Joseph Lead Company began drilling mine shaft.
1973	St. Joseph Lead Company began production.
1973-1977	Mill complex and surface facilities constructed at Brushy Creek mine.
1983	Mine and mill shut down.
1986	Doe Run acquired St. Joseph Lead Company and took over operation of Brushy Creek Mine.
1989	Mine and mill operations resume.
Ca. 1991	Mill shut down.
1997/98	Mill operation resumes.

The Brushy Creek Mine is located centrally within the Viburnum Trend. Mining operations occur approximately 1,100 feet below ground surface. The layout of the Brushy Creek Mine is shown in Figure 1-2.

1.2 OBJECTIVES

As stated above, the main objective of this UGWMP is to evaluate the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility. This main objective is met through the following:

- Understanding of the sources, quantity and movement of water through the mine.
- Understanding of the quality of water entering, moving through, and leaving the mine, with respect to the target constituents of interest.
- Identification and evaluation of potential control measures for reducing water volumes, metals concentrations, or both in the mine.

Each of these items is discussed in this plan. The UGWMP also presents an assessment of the technical feasibility of various potential control measures for the Brushy Creek Mine, as well as a plan for further investigation or implementation of potentially technical feasible control measures, based on whether such measures are likely to reduce metals loading and whether they are cost-effective.

1.3 UNDERGROUND WATER MANAGEMENT TEAM

Underground water management for the Brushy Creek Mine will be the responsibility of the individuals named in Table 1-2.

Table 1-2. Brushy Creek Mine Underground Water Management Team.

Job Title	Name	Contact Information	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	P.O. Box 500 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mine Manager	Greg Sutton	P.O. Box 500 Viburnum, MO 65566 573-626-2001	Oversight and management of Doe Run Mining Operations
Brushy Creek General Mine Supervisor	Steve Kearns	10827 Highway KK Boss, MO 65440 573-689-2228 x 4218	Brushy Creek UGWMP Primary Oversight, Implementation, and Record-Keeping
Brushy Creek Mine Superintendent	Randy Hanning	10827 Highway KK Boss, MO 65440 573-689-2228 x 4218	Brushy Creek UGWMP Secondary Oversight, Implementation, and Record-Keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573-689-4535	Environmental data collection, management, and reporting

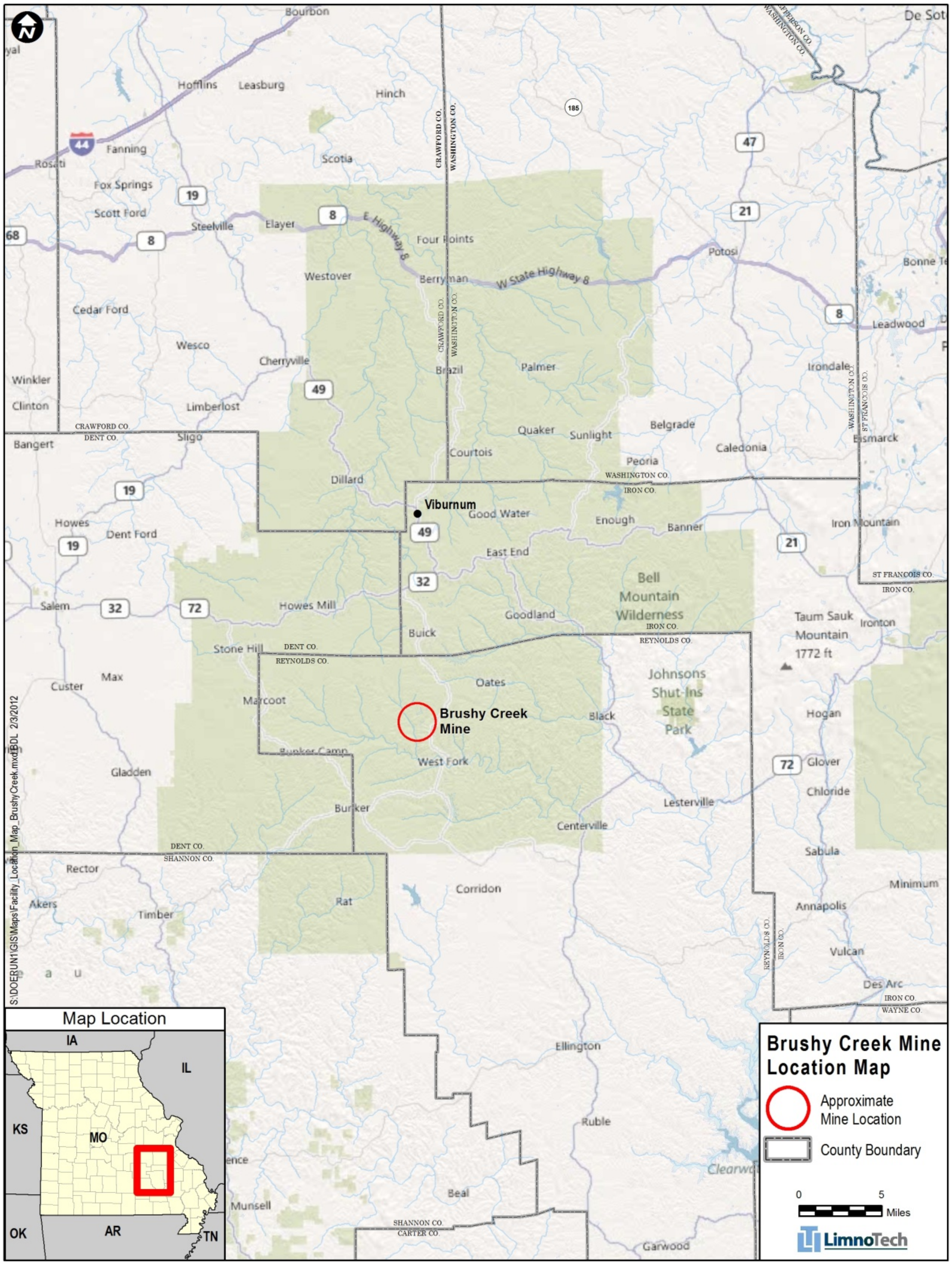


Figure 1-1. Location of the Brushy Creek Mine.

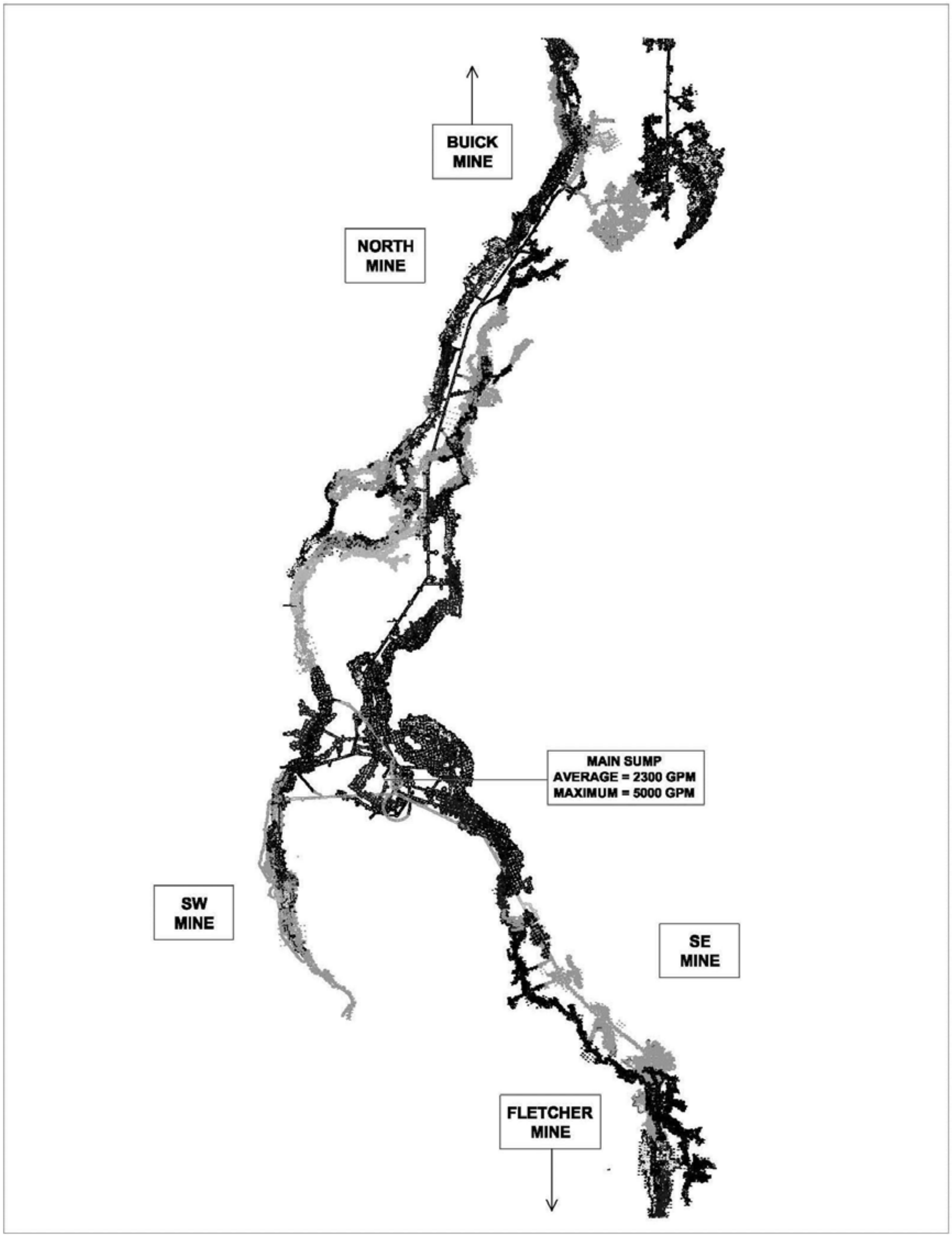


Figure 1-2. Layout of the Brushy Creek Mine.

2. SUMMARY OF MINE WATER DATA

The Master UGWMP outlined the hierarchy of water management priorities listed below from highest priority to lowest.

1. Source Control
2. Water Minimization
3. Reuse or Reclamation
4. Water Treatment
5. Discharge

Because source control has been identified as the first water management priority, source identification is a fundamental part of the planning effort for potential measures to control metals loading. Load is a function of both flow and concentration. Therefore, these components were each examined independently at the Brushy Creek Mine, as described below.

2.1 WATER SOURCES AND MOVEMENT

An inventory of water in the Brushy Creek Mine was compiled for this plan based on the best available information and includes the following components:

- Total mine water flows
- Sources of mine water
- Current underground management of mine water

Each of these components is described below.

2.1.1 Total Mine Water Flows

Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Brushy Creek Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-1.

Table 2-1. Mine Water Flowrates at Brushy Creek Mine.

Quantity	Value
Average Flow Pumped to Surface (current)	2,300 gpm
Maximum Mine Water Pumping Capacity (current)	5,000 gpm

Flow data are not currently recorded at the mine water sump, but are estimated from pump capacities and historical measurements. The average flow reported in Table 2-1 represents Doe Run's best estimate based on available information. The maximum pumping capacity is based only on pump capacity and does not reflect maximum flows actually pumped from the mine. It is known that flow rate can vary over time depending on factors such as season or where the mine is being advanced, however the values in Table 2-1 represent the best available estimate.

2.1.2 Sources of Mine Water

Water enters the Brushy Creek Mine mainly through general seepage, with some minor flows from shafts. Given the diffuse nature of most water entering the mine it is difficult, if not impossible, to accurately measure all sources. However, mine water flows were measured at some key locations in the Brushy Creek Mine to support preparation of this plan. Based on these flow measurements and information provided by Doe Run personnel, the major flow distribution of mine water pumped to the surface at Brushy Creek is as follows:

- Approximately half of the total mine water flow at Brushy Creek (approximately 1,000 gpm on average) is from the north mine.
- Approximately one third of the total mine water flow at Brushy Creek (approximately 700 gpm on average) is from the southwest mine.
- Approximately one fifth of the total mine water flow at Brushy Creek (approximately 600 gpm on average) is from the southeast mine.

The flow distribution is depicted schematically in Figure 2-1. It should be noted, as indicated in Figure 2-1, that mine water at the north end of the Brushy Creek Mine is actually pumped north to Buick Mine for management. The demarcation for the flow split is indicated in Figure 2-1 by a line crossing the drift below the arrow labeled “to Buick”. Water is pumped from the 15 Undercut (15UC) sump at a rate of approximately 200 to 250 gpm[1].

Flow measurements were collected by Doe Run and LimnoTech staff at several locations in Brushy Creek Mine on January 26, 2012 as shown in Figure 2-1. Measurements were collected using a velocity meter and dimensional measurements of ditches (width and depth). The measurements provide an indication of flowrates for that day and the total flows measured (2,900 gpm) were somewhat (26% to 32%) higher than the total average flow estimate of 2,300 gpm, but generally corroborate this average flow range, as some flow variability is expected. Flows into Brushy Creek Mine, as with all mines, vary over time as a result of several factors including, but not necessarily limited to: recent precipitation, changing location of mining activities (which may encounter new fractures, boreholes, etc.), and in-mine pumping operations. With respect to the latter item, if a particular mine water pump is shut down for maintenance, higher pumping rates may be needed when pumping is resumed to “catch up”.

To evaluate flow variability, an ISCO 4230 flow meter and pipe metering insert were installed in the ditch downstream of the 76 ROADFACE and CDH 10 discharges to gather flow information for an extended period. The meter collected readings every 15 minutes from 1/26 through 2/10/12. The average flow measured at this location during the period was 275 gpm. Measured flow rates varied from 224 to 295 gpm,

[1] The flow that is pumped to Buick Mine constitutes part of the 500 gpm flow depicted in the southwest part of the mine in Figure 2-1 of the *Underground Water Management Plan for Buick Mine*.

indicating a short-term variability of up to 19% of the average flow of 275 gpm, corroborating the variability of mine water flows at Brushy Creek Mine.

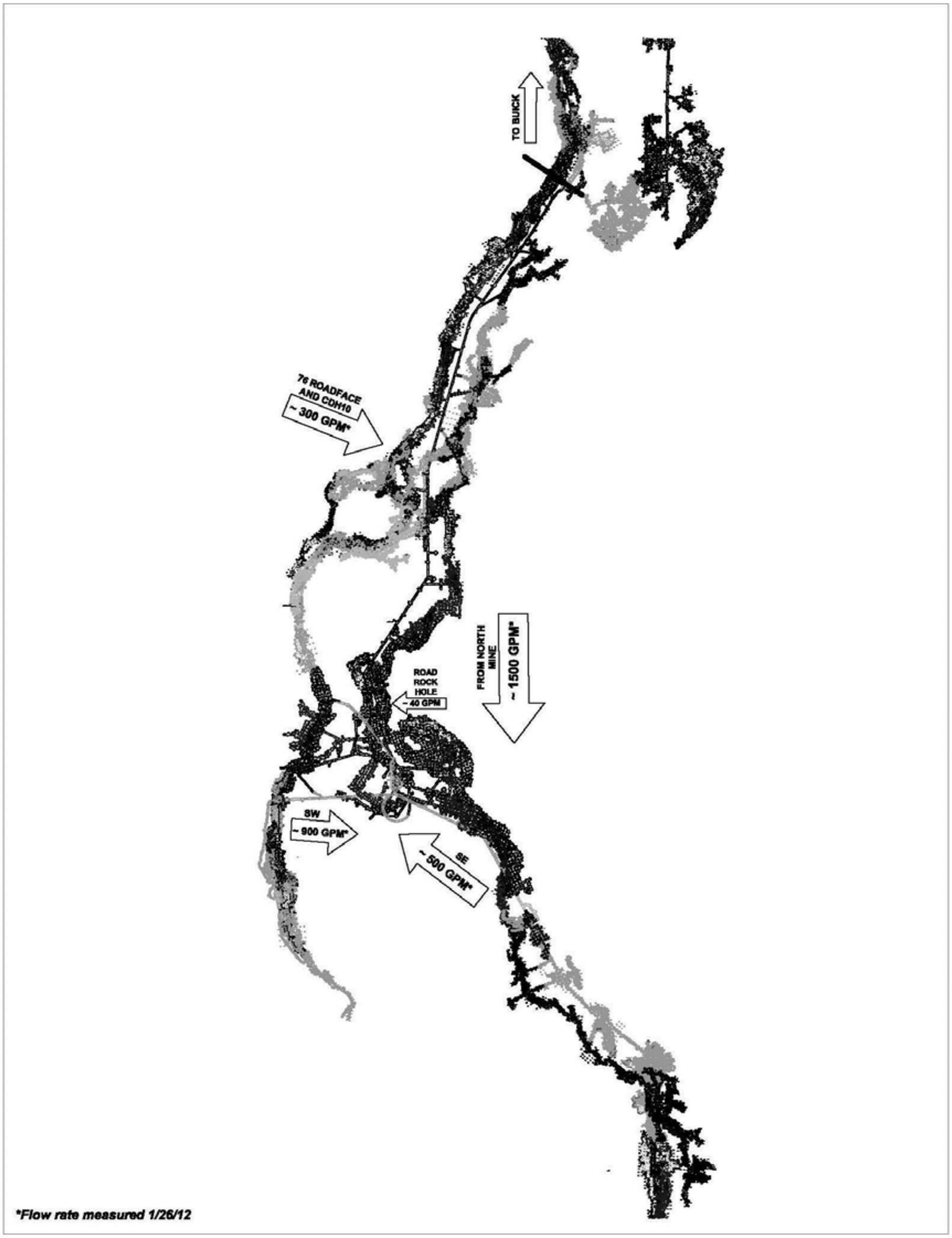


Figure 2-1. Measured Mine Water Flows for the Brushy Creek Mine on January 26, 2012.

2.1.3 Current Underground Water Management Practices

Current practices to manage mine water at Brushy Creek Mine are primarily focused on maintaining safe and workable conditions in the mine and are not specifically designed to maintain or improve water quality. These practices include the following:

- Piping – Piping of water through the mine has historically been performed to facilitate transfer pumping from one location to another, where mine grades prevent gravity flow. Piping is discussed in greater detail in Section 3.1.1.
- Sump cleaning – Sump cleaning, or mucking as it is called by mine personnel, has historically been performed, as needed, to maintain performance of the mine water sump pumps. Sump mucking is discussed in greater detail in Section 3.4.9.
- Corehole plugging **–** Plugging of coreholes that contribute significant flows, where feasible, has historically been performed at Brushy Creek Mine. Corehole plugging is discussed further in Section 3.3.

Although it may not be their specific intent, these practices may have an incidental benefit of protecting water quality. These and other potential water management practices to preserve or improve water quality are discussed in greater detail in Section 3 of this Plan.

2.2 MINE WATER QUALITY

To support development of this and other water management plans at Doe Run mine/mill facilities, a water quality sampling program was implemented between December 2010 and June 2011. Three rounds of underground water sampling were performed at each mine. The details of the underground sampling program, including the sampling results, are presented in the Underground Water Sampling and Analysis Plan Report (LimnoTech, August 4, 2011). Sampling locations for these events are shown in Figure 2-2. A more detailed map of Brushy Creek Mine showing sample locations, water flow paths, pump information, and sampling results for total and dissolved lead and zinc, is included as Appendix A.

These data were evaluated to better understand mine water quality at Brushy Creek Mine and to discern factors that may improve or degrade mine water quality. Because the purpose of this UGWMP and the surface water management plan at Brushy Creek is to be part of a comprehensive effort above and below ground to attain compliance with future final Missouri State Operating Permit (MSOP) future final limits for the discharge of mine water and other sources to waters of the State, the mine water data were evaluated in reference to the future final discharge limits in the MSOP for the Brushy Creek Mine. The future final limits for the primary constituents of interest for outfall 001 and outfalls 002/003 are summarized in Tables 2-2 and 2-3.

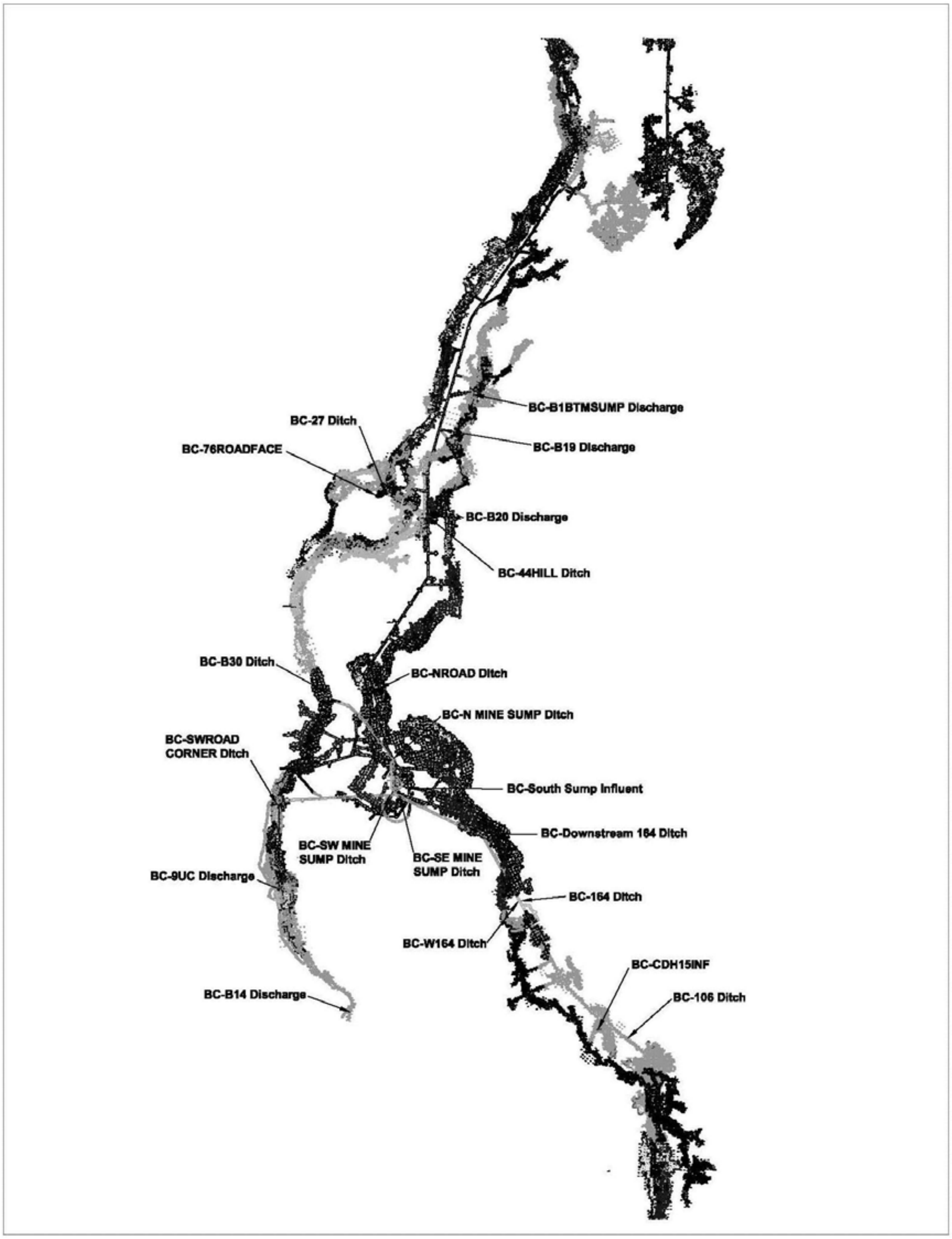


Figure 2-2. Mine Water Sampling Locations for the Brushy Creek Mine.

Table 2-2. Future Final MSOP Limits for the Brushy Creek Mine (Outfall 001).

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.3	0.6
Copper, total recoverable	61.0	30.4
Lead, total recoverable	23.3	11.6
Zinc, total recoverable	370.0	184.6

Table 2-3. Future Final MSOP Limits for the Brushy Creek Mine (Outfalls 002/003).

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	0.7	0.3
Copper, total recoverable	20.8	10.4
Lead, total recoverable	10.9	5.4
Zinc, total recoverable	195.0	97.0

The findings of this evaluation are presented in the following sections.

2.2.1 Incoming Mine Water Quality

Incoming mine water quality at Brushy Creek Mine is characterized by samples collected at two locations: "76ROADFACE" and "CDH15INF". 76ROADFACE is located north of the main mine water sumps, and the CDH15INF location is in the southeast part of the mine. No influent mine water samples were collected in the southwest part of the Brushy Creek Mine because no specific locations were identified where incoming mine water could be safely accessed for sampling. It should be noted that a sample was also collected from the CDH15INF location on May 26, 2011, but the results showed very high TSS and total metals. Inspection of the field notes revealed that the sample had been collected from a leaking drill water pump, which would not be considered representative of the location. This likely explains the elevated TSS and metals. Because the sample from this event is not representative of incoming mine water, the sample was excluded from this analysis. Three valid samples from 76ROADFACE, and two valid samples from CDH15INF were taken during the underground sampling program. The data are represented in Table 2-4.

Comparing these results to the future final discharge limits presented in Tables 2-2 and 2-3 shows that, in general, concentrations of primary metals in incoming mine water are generally below the future final permitted discharge limits, with the following exceptions:

- One sample collected at CDH15INF exceeded the 002/003 future final monthly average discharge limit for total cadmium.
- One sample collected at CDH15INF exceeded the future final monthly average discharge limits for total lead.
- One sample collected at CDH15INF exceeded the future final daily 002/003 monthly average discharge limit for zinc.

No samples exceeded future final monthly average or daily maximum copper or TSS limits. It is expected that incoming mine water is more accurately represented by the samples from the 76ROADFACE location because the samples collected from CDH15INF were actually collected from a mine water pumping box and had already undergone some exposure to mine workings. The elevated cadmium and zinc concentrations at CDH15INF could be a function of the rock strata through which the water flows before entering the mine. It is not certain that all water entering the mine will have the same quality as is reflected in these samples.

Table 2-4. Incoming Mine Water Quality at Brushy Creek Mine.

Location	**Sampling Date**	**Parameter**				
		Total Cadmium (µg/L)	Total Copper (µg/L)	Total Lead (µg/L)	Total Zinc (µg/L)	TSS (mg/L)
BC-76ROADFACE	12/7/2010	0.15	ND (0.5)	3.9	15.5	ND (5)
BC-76ROADFACE	3/22/2011	ND (0.08)	ND (0.5)	0.16	ND (5)	ND (5)
BC-76ROADFACE	5/26/2011	0.07	ND (0.97)	4.5	25	6
BC-CDH15INF	12/7/2010	0.022	1.2	2.6	4	20
BC-CDH15INF	3/22/2011	0.31	ND (0.5)	28.1	97.2	ND (5)

2.2.2 Comparison of Incoming and Outgoing Mine Water

Inspection of the water data collected throughout Brushy Creek Mine shows that samples at many locations contain concentrations of target metals above the future final permitted effluent limits, so incoming and outgoing mine water (i.e., mine water pumped to the surface) were compared to discern which of those metals exceed their respective discharge limits.

These comparisons of samples taken of incoming mine water at 76ROADFACE and CDH15INF with mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-3, 2-4, 2-5, and 2-6, respectively. As stated above, incoming mine water quality is characterized by samples collected at 76ROADFACE and CDH15INF.

Because there is no direct sampling access to the main sumps, outgoing mine water is characterized by the samples collected at N MINE SUMP DITCH, SE MINE SUMP DITCH, and SW MINE SUMP DITCH. Ideally, samples characterizing the outgoing mine water would be collected from a location as close as possible to the mine water sump pumps but, due to the construction of the sumps at Brushy Creek Mine, such a location cannot be safely or easily accessed. Because the main mine water sumps at Brushy Creek Mine are sampled in the influent ditch, they do not reflect any settling that may occur in the mine water sumps before mine water is pumped to the surface. Two samples were collected at each of these locations in the underground sampling program. The following observations can be made from the data shown in Figures 2-3, 2-4, 2-5, and 2-6:

- Cadmium: One incoming mine water samples from CDH15INF exceeded the future final monthly average cadmium effluent limits for outfall 002/003. All future final limits were exceeded in the mine sump ditch samples.
- Copper: All samples of incoming mine water were well below the future final effluent limits for copper. All mine sump ditch samples exceeded at least one of the future final monthly average limits for copper.
- Lead: One of the two samples at CDH15INF exceeded all of the future final effluent limits for lead. The other incoming mine water location (76ROADFACE) sampled did not exceed the future final limits during the 2011 sampling program. All mine sump ditch samples exceeded the monthly average and daily maximum future final limits for lead.
- Zinc: Incoming mine water samples were below the future final effluent limits for zinc with the exception of one sample at CDH15INF, which exceeded the 002/003 monthly average future final effluent limit for zinc. All mine sump ditch samples exceeded the monthly average and daily maximum future final limits for zinc.

These results suggest that exposure of mine water to the mine workings at Brushy Creek can result in significant degradation of water quality, in part likely due to the increase in total suspended solids. The relationship between increased metals concentrations and increased suspended solids in mine water is discussed in Section 2.2.4 of this plan.

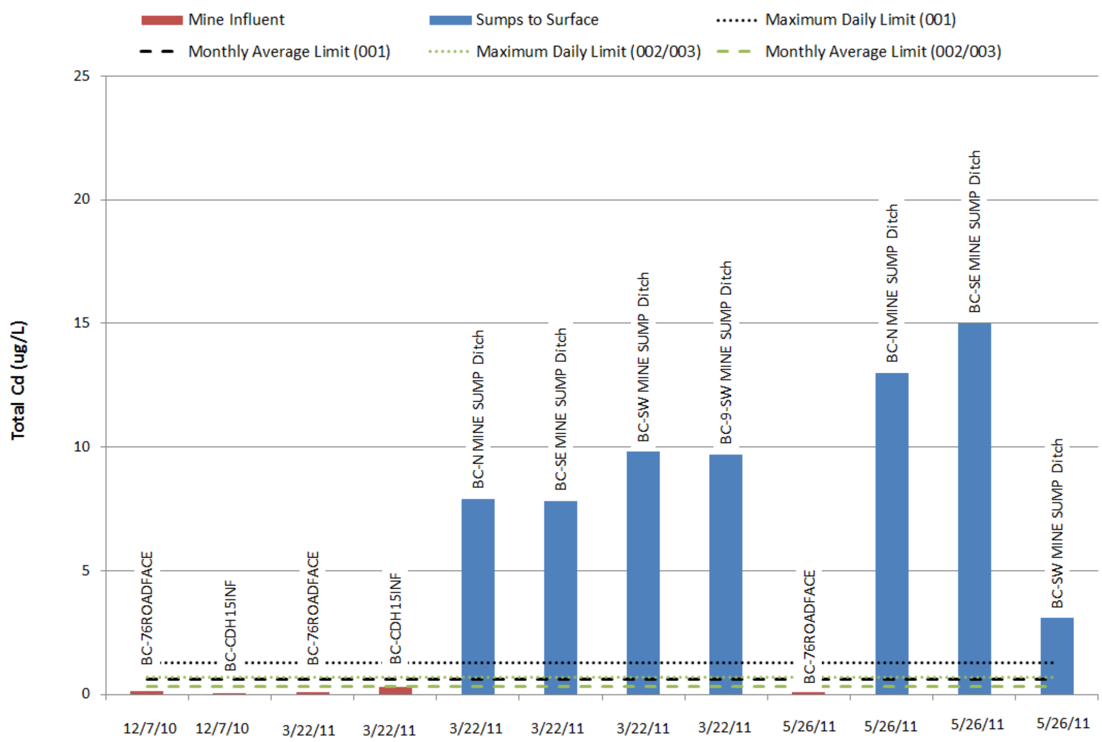


Figure 2-3. Incoming vs. Outgoing Mine Water Quality at Brushy Creek Mine: Total Cadmium.

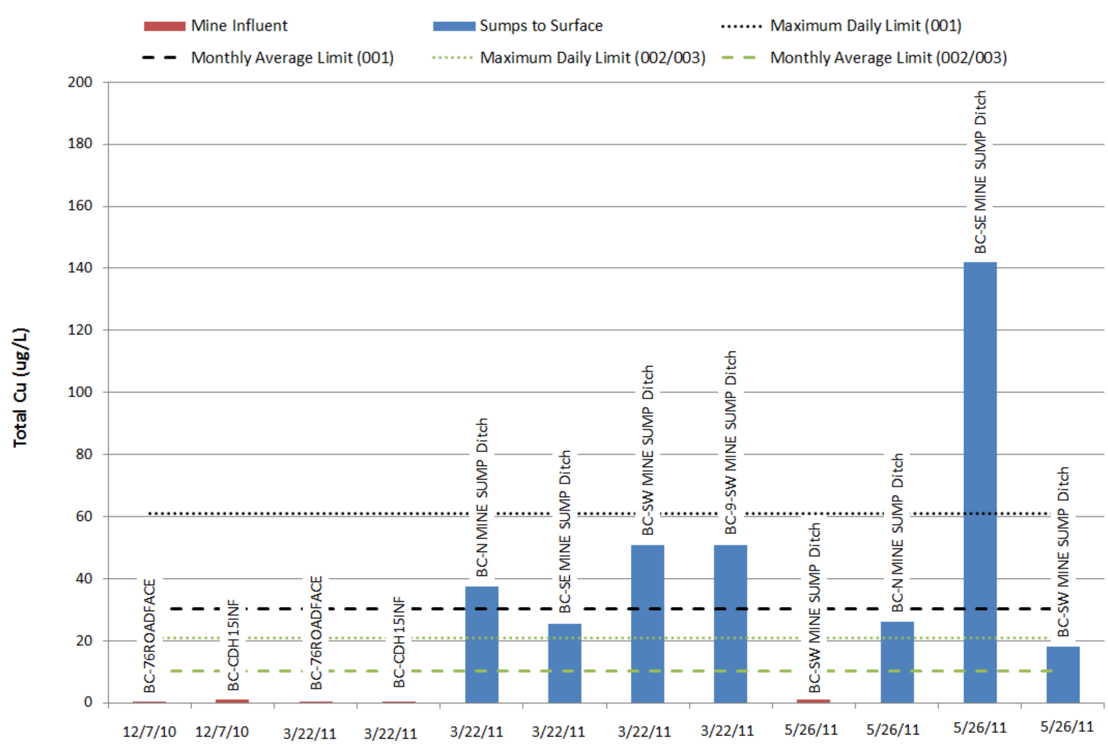


Figure 2-4. Incoming vs. Outgoing Mine Water Quality at Brushy Creek Mine: Total Copper.

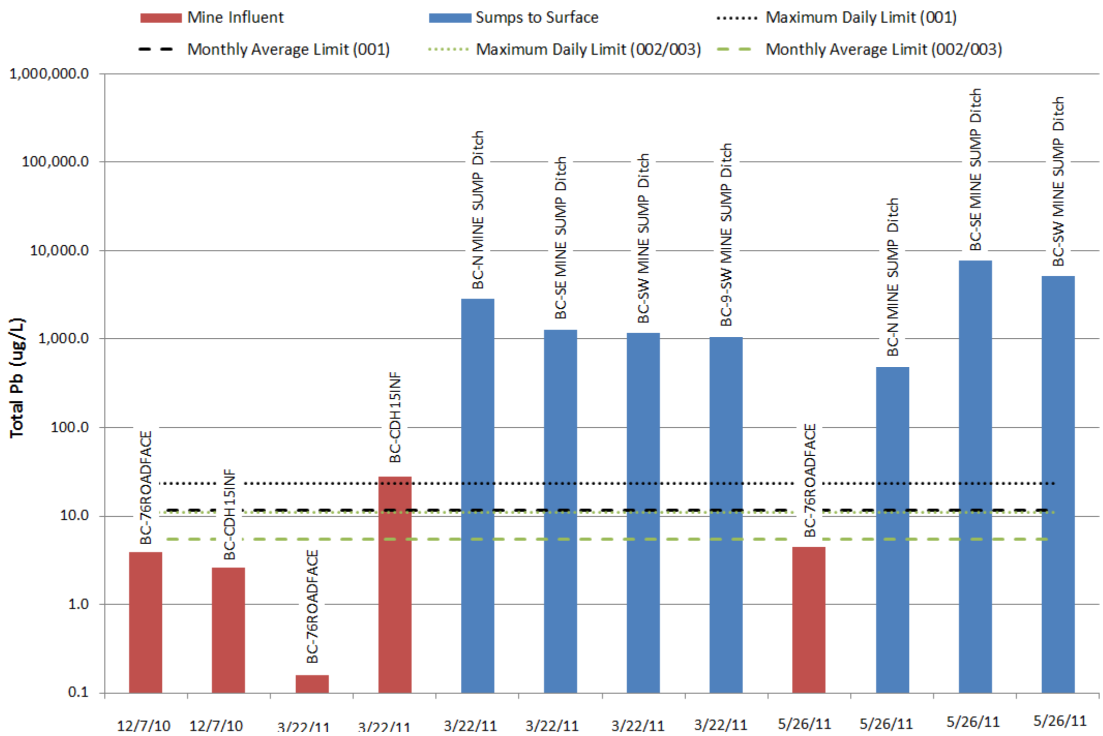


Figure 2-5. Incoming vs. Outgoing Mine Water Quality at Brushy Creek Mine: Total Lead (Note: log scale).

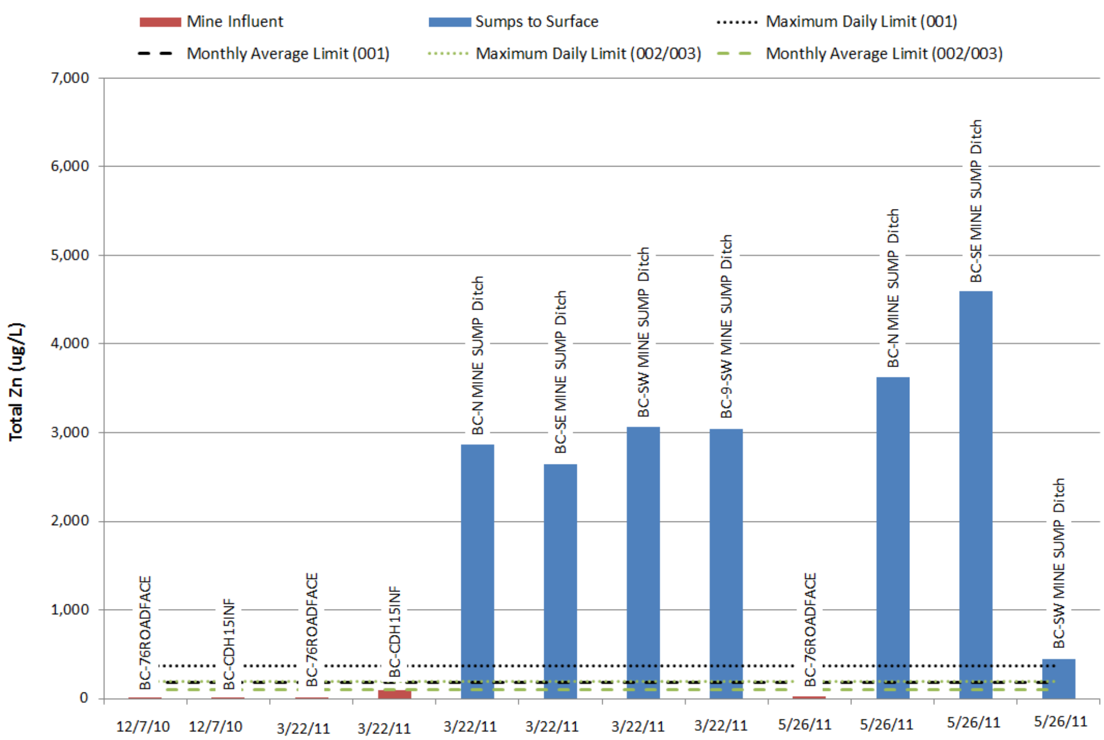


Figure 2-6. Incoming vs. Outgoing Mine Water Quality at Brushy Creek Mine: Total Zinc.

2.2.3 Spatial Variation in Mine Water Quality

A majority of the mine water that is currently pumped to the surface at Brushy Creek comes from the north end of the mine. However, although the north mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the three parts. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the north, southeast, and southwest were compared. The north mine sampling locations include 27 Ditch, B30 Ditch, 44HILL Ditch, B19 Discharge, B1BTMSUMP Discharge, B20 Discharge, NROAD Ditch, and N MINE SUMP Ditch. The southeast mine sampling locations include 106 Ditch, 164 Ditch, W164 Ditch, Downstream 164 Ditch, and SE MINE SUMP Ditch. The southwest mine sampling locations include B14 Discharge, 9UC Discharge, SWROAD CORNER Ditch, and SW MINE SUMP Ditch. Figures 2-7 through 2-10 show the comparison box plots of mine water quality between the north, southeast, and southwest parts of Brushy Creek mine. The box plots can be interpreted as follows:

- The dash in the center of each box represents the median value of the data set.
- The lower and upper edges of the box are the first and third quartiles (the first quartile represents the value that is equal to or greater than 25% of the data and the third quartile represents the value that is equal to or greater than 75% of the data), respectively.
- The lower and upper whiskers are the 5th and 95th percentile values.

For ease of comparison, each plot also shows the future final effluent limits for that metal in the MSOP. The following observations can be made from these plots:

- Cadmium: Cadmium tends to occur over a wider range of concentrations in the southwest mine than in the north or southeast mine, with the 95th percentile concentration measured in the southwest mine (45 μg/L) being three times the north mine 95th percentile (15 μg/L) and nearly three times higher than the southeast mine 95th percentile (12 μg/L). The 5th percentile measured cadmium concentration in the southwest mine was three to four times lower than other parts of the mine. Most mine water samples in all parts of the mine exceeded both the monthly average and daily maximum cadmium future final effluent limits for both outfalls.
- Copper: Copper in the southwest also occurs at slightly higher concentrations than in the north and southeast mine. The median concentration in the southwest (18 μg/L) is higher than the median for the north and southeast (10 μg/L). Again, these differences are slight and copper concentrations throughout the mine are generally comparable.
- Lead: With the exception of one sample collected in the north mine, all mine water samples exceeded both the monthly average and maximum daily future final effluent limits for both outfalls. Lead tends to occur at higher concentrations in the southeast mine than in the north or southwest mine, with

the southeast median concentration (2,825 µg/L) being significantly higher than the north mine median (472 µg/L) and the southwest median (482 µg/L).

- Zinc: Zinc concentrations appear to be similar in the north and southwest mine where all samples exceeded both the monthly average and maximum daily future final effluent limits for both outfalls. The southeast median concentration (519 µg/L) is approximately 4 times less than the north (2,255 µg/L) and southwest (2,080 µg/L) median concentrations, respectively.

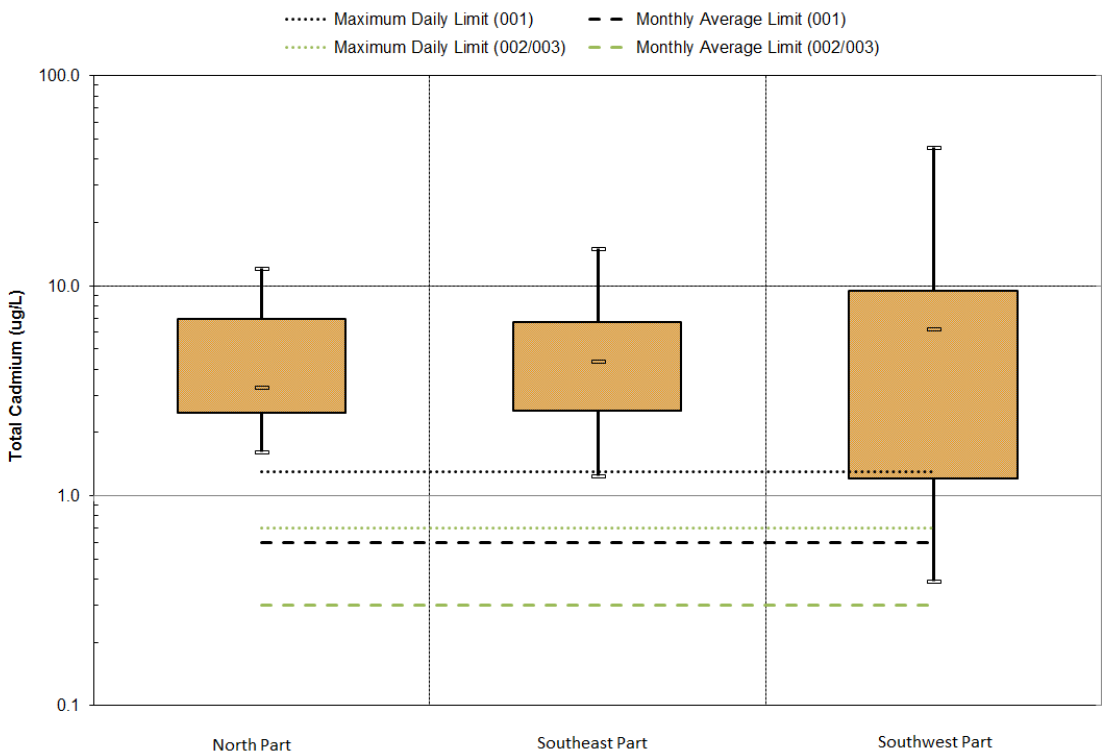


Figure 2-7. Comparison of Total Cadmium between North, Southeast, and Southwest Parts of Brushy Creek Mine.

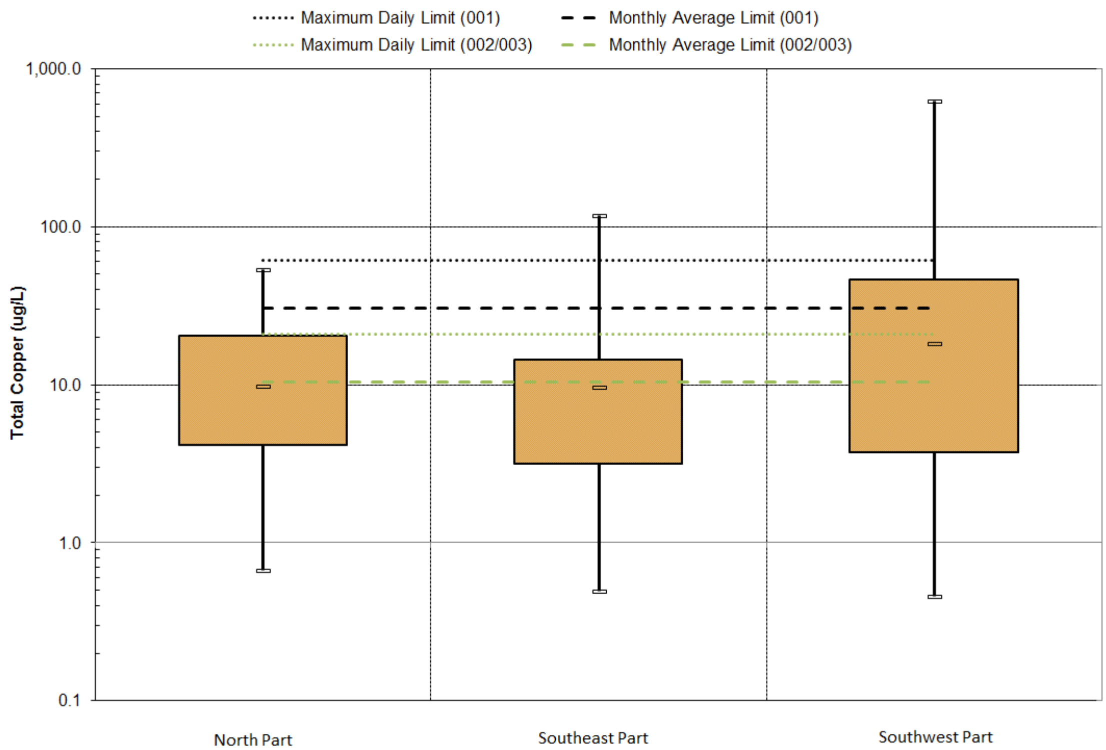


Figure 2-8. Comparison of Total Copper between North, Southeast, and Southwest Parts of Brushy Creek Mine.

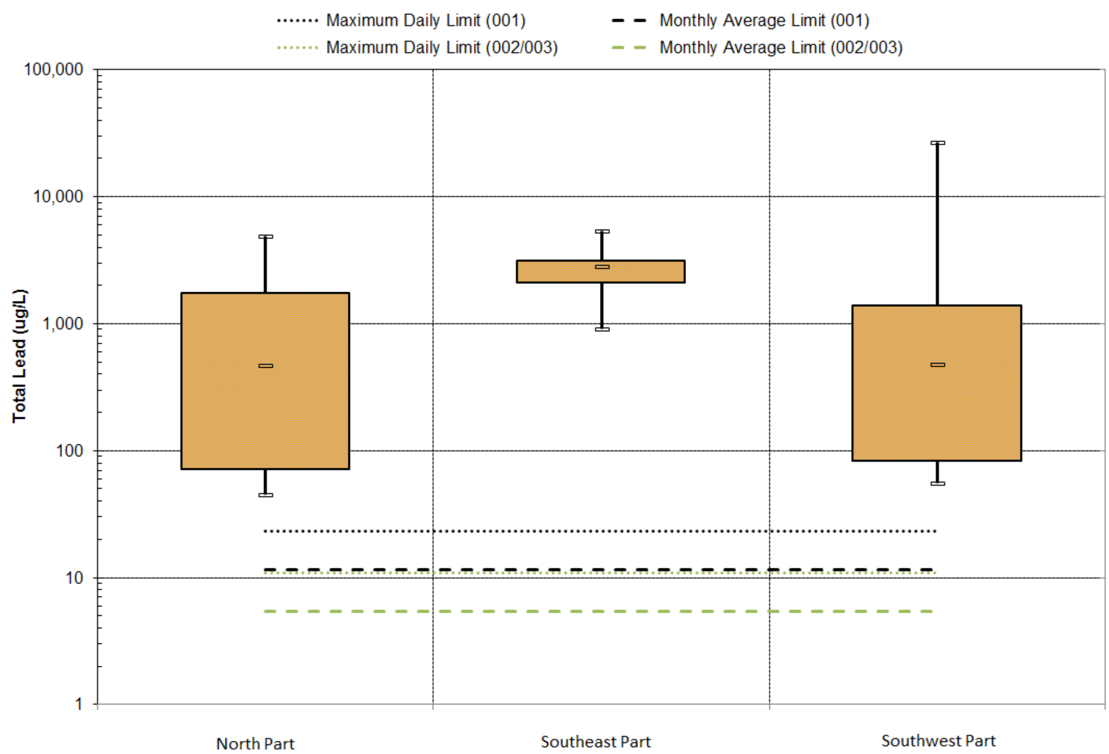


Figure 2-9. Comparison of Total Lead between North, Southeast, and Southwest Parts of Brushy Creek Mine.

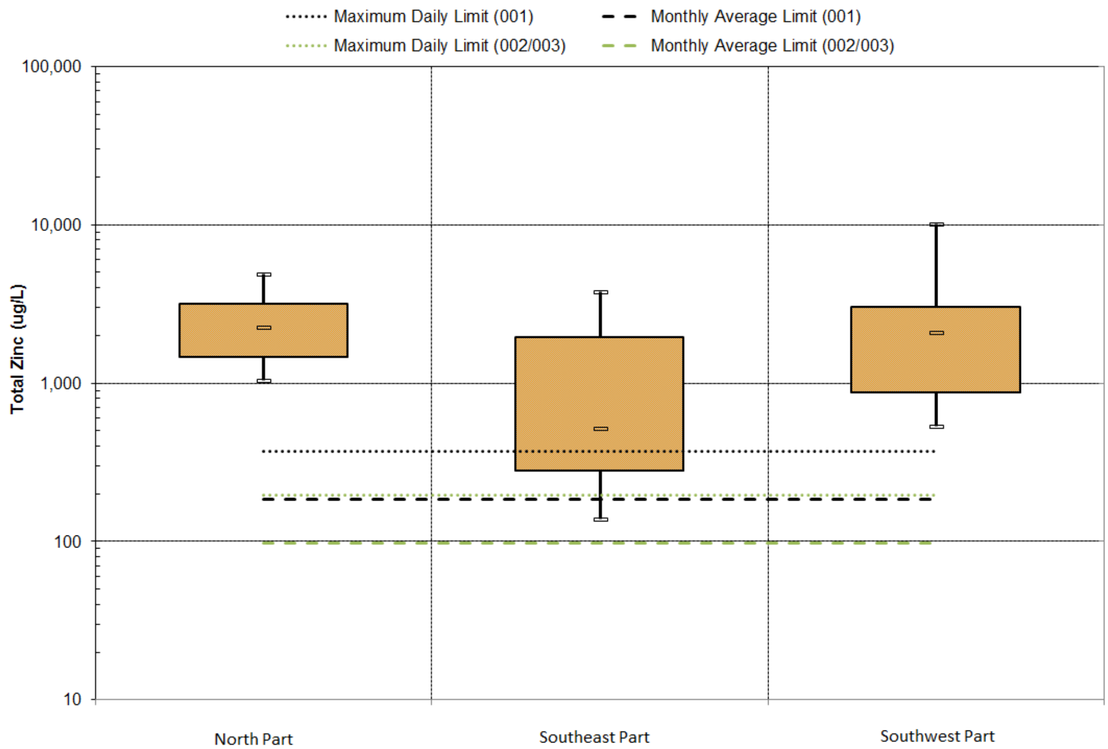


Figure 2-10. Comparison of Total Zinc between North, Southeast, and Southwest Parts of Brushy Creek Mine.

2.2.4 Relationship Between Solids and Metals in Mine Water

Data from the Brushy Creek Mine show that, in general, incoming mine water has relatively low metals concentrations compared to mine water that is pumped to the surface and that the concentrations of metals are significantly increased by exposure to the mine workings (Section 2.2.2). Therefore, the Brushy Creek Mine data were evaluated to assess the relationship between metals and suspended solids. Figures 2-11 through 2-14 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS). These results show varying relationships of metals with TSS at Brushy Creek mine. The correlations are summarized in Table 2-5.

Table 2-5. Correlations of Total Metals with Total Suspended Solids at Brushy Creek Mine.

Parameter	Correlation with TSS (r^2 value)
Cadmium, Total	0.88
Copper, Total	0.95
Lead, Total	0.97
Zinc, Total	0.64

The r-squared values[2] in Table 2-5 indicate that total cadmium, total copper, and total lead are more closely correlated to TSS than zinc. This suggests that increases in TSS, resulting from exposure of incoming mine water to mine workings, are a leading contributor to increases in cadmium, copper, and lead at Brushy Creek. TSS does not appear to affect concentrations of zinc as strongly.

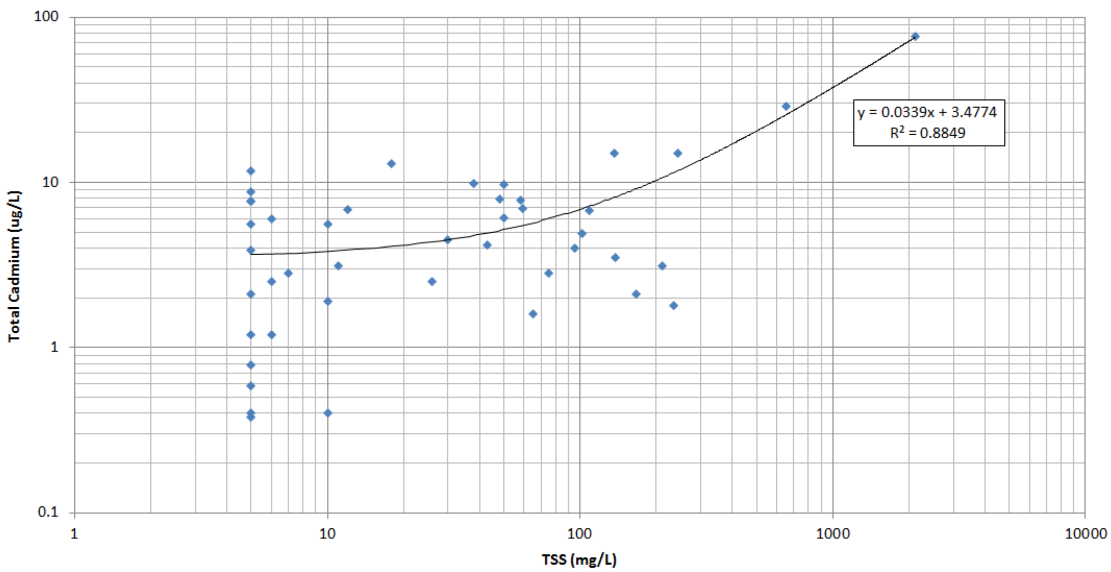


Figure 2-11. Correlation of Total Cadmium with Total Suspended Solids at Brushy Creek Mine.

[2] One way of interpreting r^2 values is that if total copper has an r^2 value of 0.95 with TSS, then TSS explains 95% of the variability of total copper in the data set.

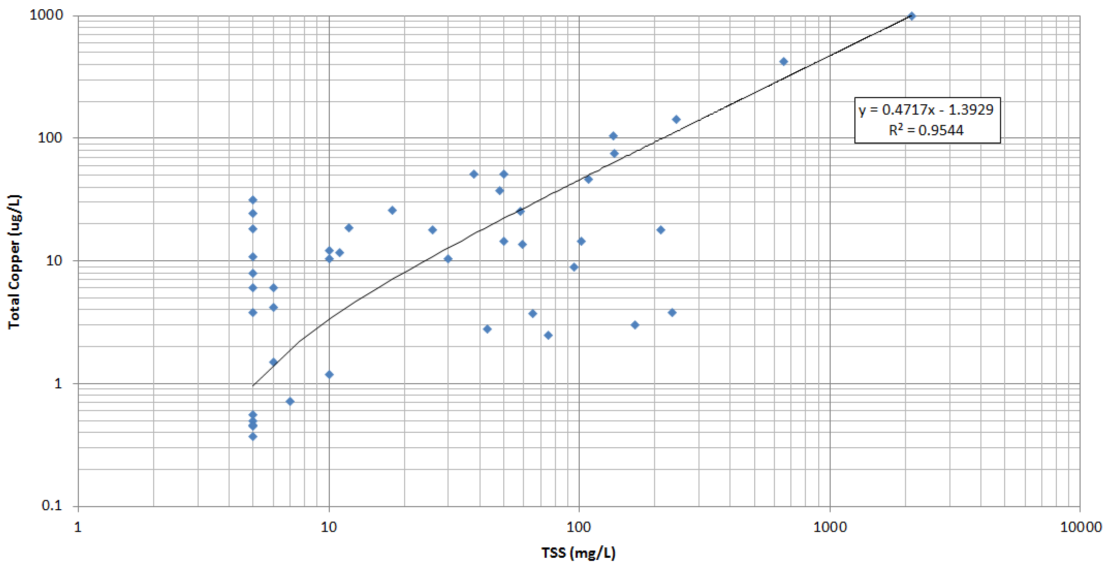


Figure 2-12. Correlation of Total Copper with Total Suspended Solids at Brushy Creek Mine.

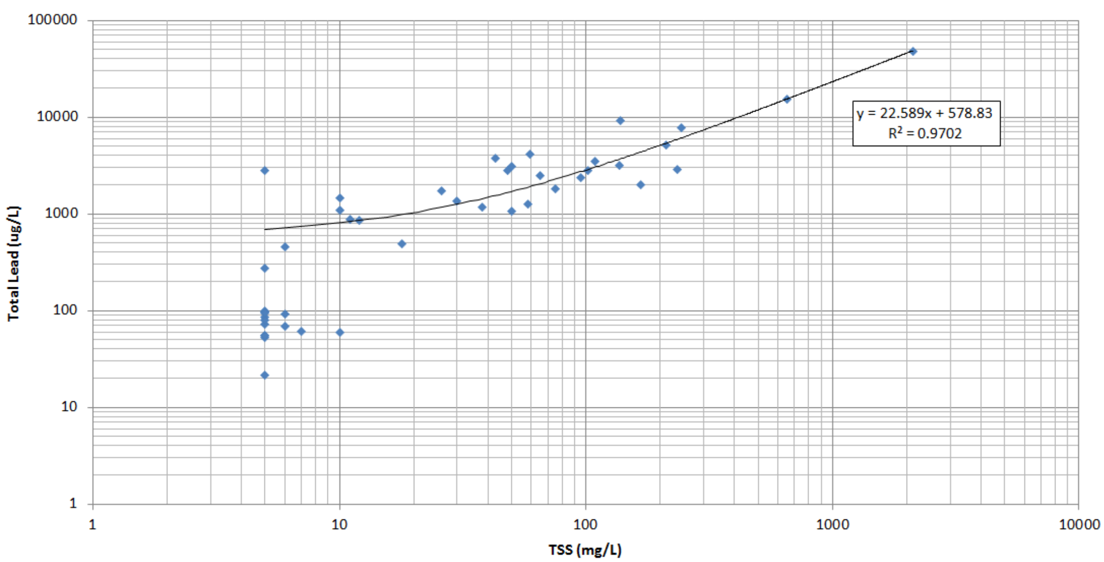


Figure 2-13. Correlation of Total Lead with Total Suspended Solids at Brushy Creek Mine.

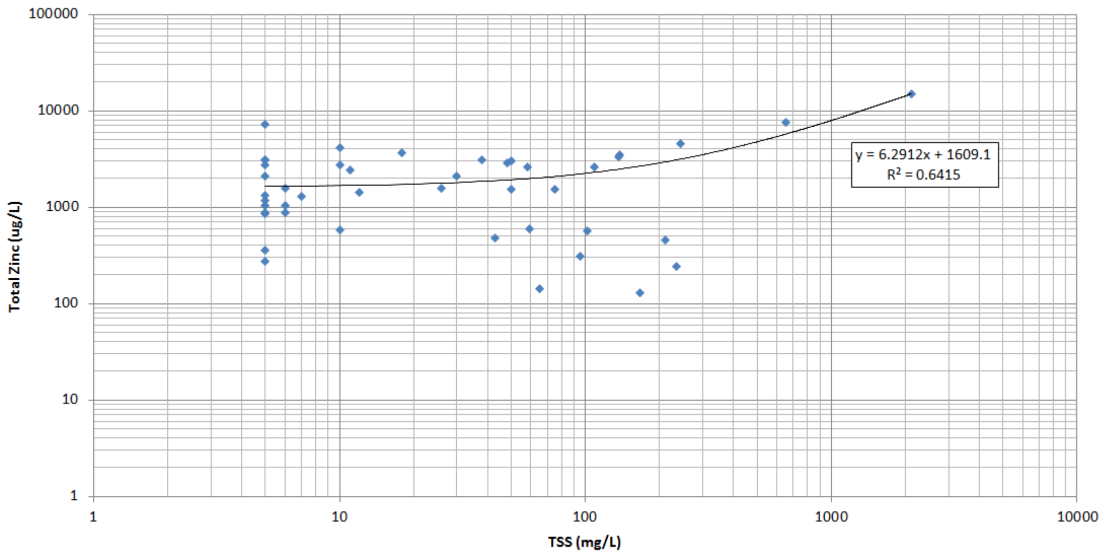


Figure 2-14. Correlation of Total Zinc with Total Suspended Solids at Brushy Creek Mine.

2.2.5 Comparison of Underground and Surface Mine Water

Mine water data collected immediately upstream of the underground sump at Brushy Creek were compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. Mine water data at the surface is represented by samples taken at the mine water box, which is located upstream of the mine water basin. The results are plotted in Figures 2-15 through 2-18 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is not possible because the underground and surface samples were not collected on the same dates and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made. Specific observations are as follows:

- Cadmium in the mine sump ditch and surface samples exceed both the monthly average and daily maximum future final limits in all samples.
- Copper results were variable with two of the three surface samples exceeding both the monthly average and daily maximum future final limits. One of the mine sump ditch samples exceeded all of the monthly average and daily maximum future final limits.
- Lead in the mine sump ditch and at the surface exceeds the monthly average and daily maximum future final limits in all samples.
- Zinc in the mine sump ditch and at the surface exceeds the monthly average and daily maximum future final limits in all samples.

Ongoing sampling at Brushy Creek mine will include underground and surface mine water and these data will continue to be evaluated as they become available.

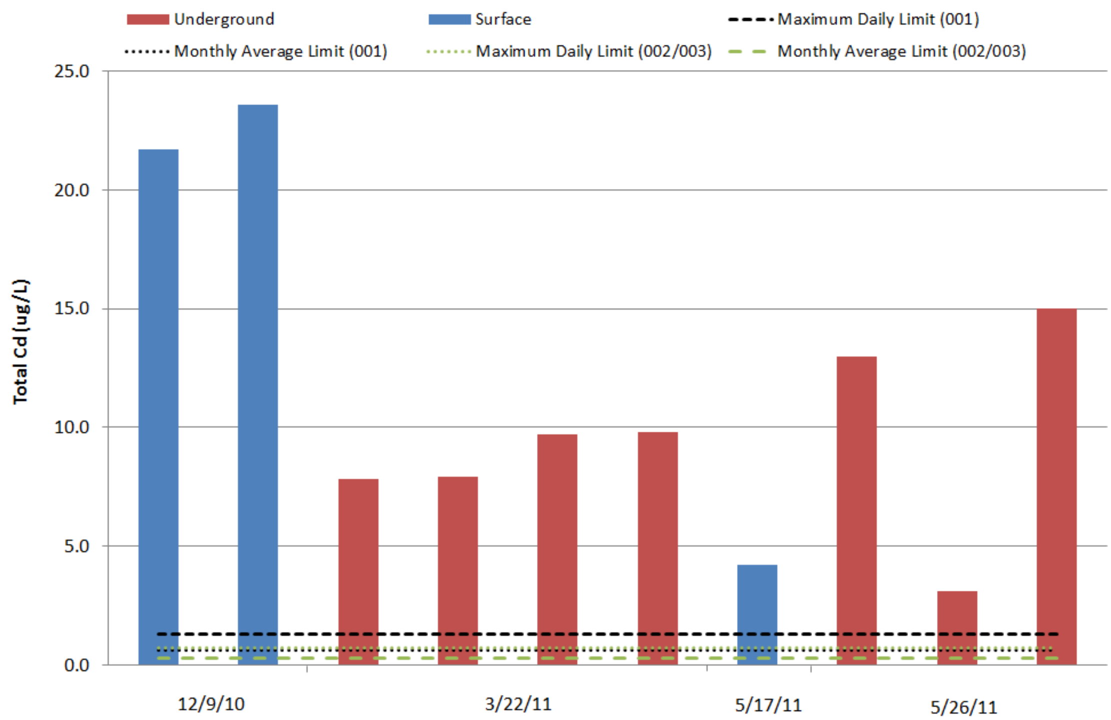


Figure 2-15. Total Cadmium in Underground vs. Surface Mine Water at Brushy Creek Mine.

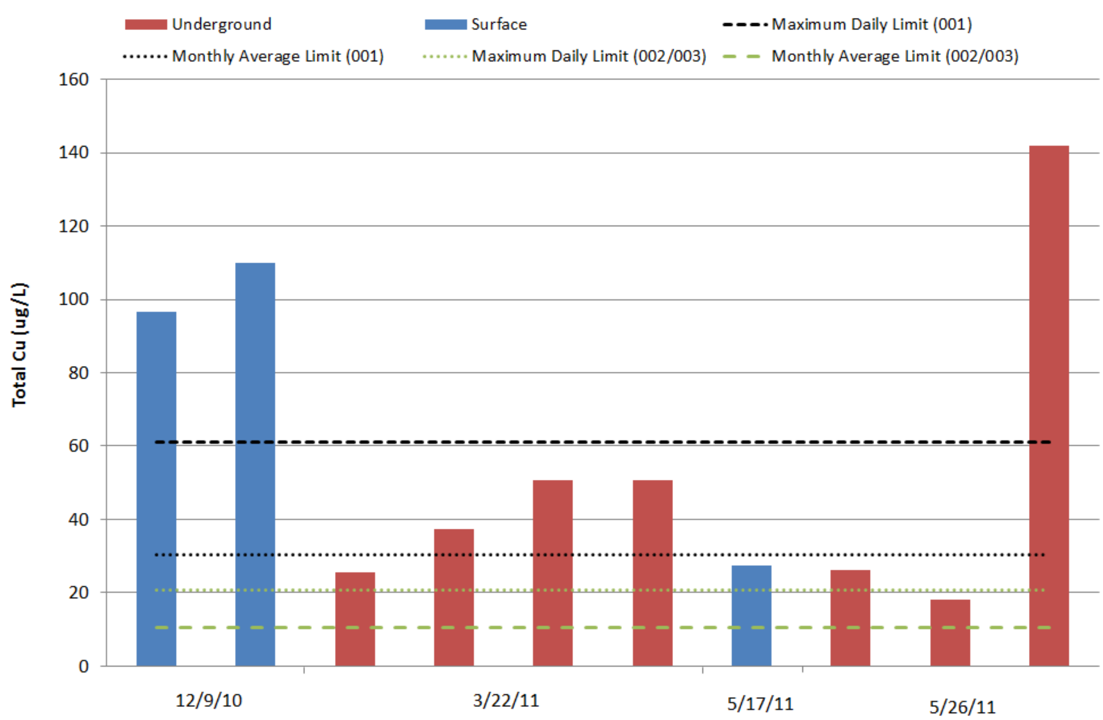


Figure 2-16. Total Copper in Underground vs. Surface Mine Water at Brushy Creek Mine.

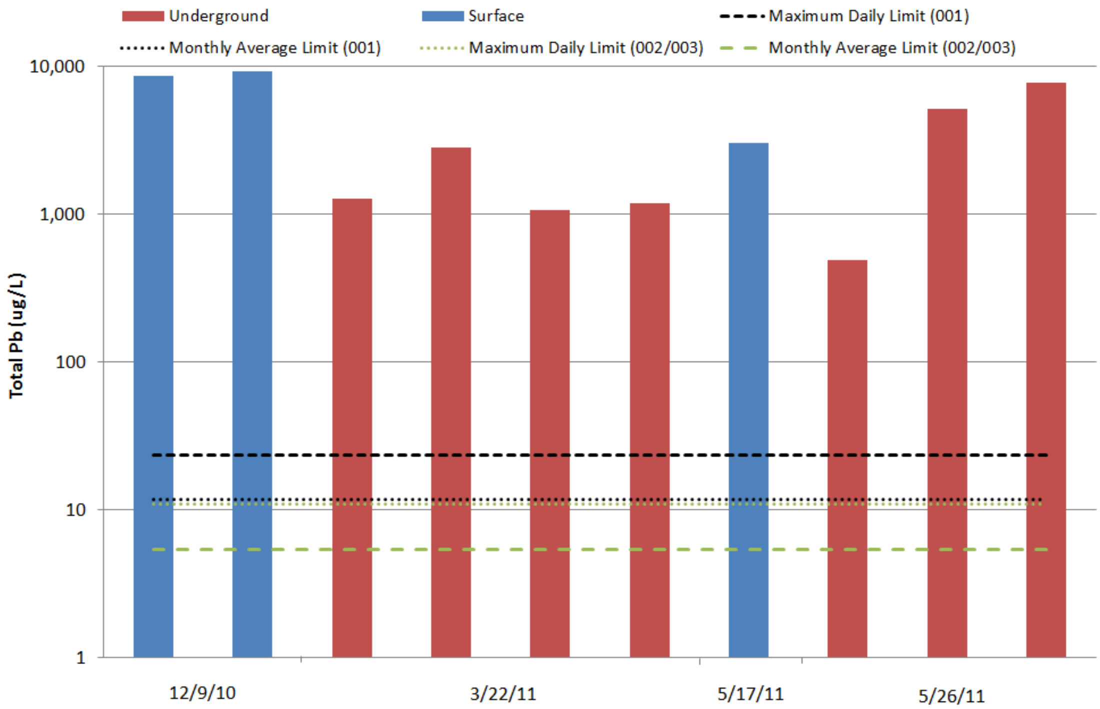


Figure 2-17. Total Lead in Underground vs. Surface Mine Water at Brushy Creek Mine.

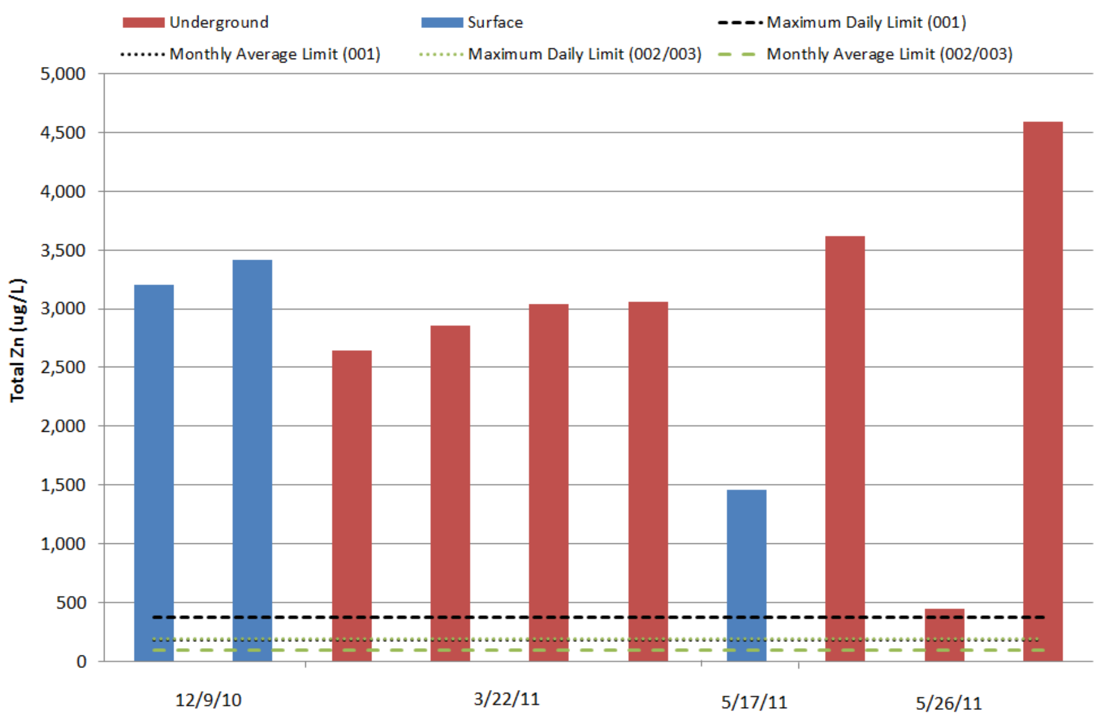


Figure 2-18. Total Zinc in Underground vs. Surface Mine Water at Brushy Creek Mine.

2.3 SUMMARY OF MINE WATER SOURCES AND CONDITIONS

The findings of the preceding discussion of mine water at Brushy Creek Mine can be summarized as follows:

- The average flow of water entering Brushy Creek Mine and being pumped to the surface is estimated at 2,300 gpm. Of this total mine water flow, slightly less than half (1,000 gpm) of the flow comes from the North part of the mine.
- Incoming mine water has relatively low metals concentrations, and exposure to the mine workings increases those concentrations.
- Total cadmium, copper, lead and zinc appear to be positively correlated with total suspended solids. Increased suspended solids in mine water appears to increase total cadmium, total lead, and total copper but does not affect total zinc as strongly.
- In general, concentrations of total cadmium, copper, lead and zinc in mine water at Brushy Creek have the likelihood to exceed future final effluent limits.
- Mine water data collected to date indicate that cadmium and copper tend to be slightly higher in the southwest part of the mine than in the north and southeast; lead tends to be significantly higher in the southeast part of the mine than in the north and southwest; and zinc tends to be higher in the southwest and north part of the mine than in the southeast.

Some possible water management approaches for Brushy Creek mine for consideration as a result of these findings, include:

- Evaluate the effectiveness, technical feasibility and cost-effectiveness of measures that minimize exposure of water entering the mine to mine workings.
- Evaluate options that are effective, technically feasible and cost-effective to minimize the introduction of suspended solids to mine water in an effort to reduce metals concentrations.

These water management approaches were used to evaluate potential water management measures, as discussed in Section 3.

This page is blank to facilitate double sided printing

3. WATER MANAGEMENT MEASURES

This section of the plan presents several potential water management strategies and evaluates them in the context of Brushy Creek Mine. In keeping with the Master Underground Water Management Plan, this section discusses the following types of possible measures:

- Isolation measures (Section 3.1)
- Treatment measures (Section 3.2)
- Groundwater interception (Section 3.3)
- Best management practices (Section 3.4)

A summary of the evaluation of these measures for Brushy Creek Mine is presented in Section 3.5. It should be noted that this Section discusses potential underground water management measures and that these measures are not necessarily all planned for implementation at Brushy Creek Mine. Section 4 describes which of these measures are planned for implementation and further evaluation of their effectiveness, technical feasibility, and cost-effectiveness at Brushy Creek Mine. It should also be noted that Doe Run is currently evaluating the technical feasibility and probable costs of treating mine water at the surface and these evaluations will provide a point of comparison with potential underground water management measures to evaluate the cost-effectiveness of those measures.

3.1 ISOLATION MEASURES

Isolation measures are practices designed to isolate mine water from materials/processes that have the potential to increase metals in the mine water. The objective of isolation technologies is to eliminate or reduce the potential for mine water to contact or be exposed to environments that have the potential to increase the metals load.

3.1.1 Piping Water

In some locations in the mine, mine water flows via gravity in roadside ditches. In some places in Brushy Creek Mine, where it is necessary to pump water due to grade changes, the water flows through pipes. In areas where there is open water in ditches and piping is not used, the water surface is exposed to loading of solids and metals from the roadways, mobilized by passing trucks and machinery. Because of this potential exposure, piping presents a potential control measure for improving water quality. A planned piping project and a general piping contingency plan are discussed in Section 4.1.2 of this Plan.

Parts of Brushy Creek Mine that are currently piped are shown on the map in Appendix A. Piping used in the mine typically consists of high density polyethylene (HDPE) pipe, with 8-inch and 10-inch diameter (nom.) being the most common size used for long runs in Doe Run mines. The unit cost for these pipe materials ranges from $7 to $10 per linear foot (l.f.) for 8” pipe and $11 to $17 per l.f. for 10” pipe.

These are materials costs based on current vendor pricing and do not include labor for installation.

Review of sampling data from Doe Run mines shows that water quality is reduced within a short distance of water entering the mine. This suggests that, for piping to be an effective control measure, water must be captured very close to the source before significant exposure to mine workings occurs. This is not possible in every circumstance. However, piping may be implemented on a localized basis at the Brushy Creek Mine as a water quality management measure where the company determines that the measure will be effective in controlling water quality and will be cost-effective.

3.1.2 Lined Channels

Roadside channels in the mine allow contact between flowing water and the underlying rock. This contact may cause an increase in metals concentration, so lining of the channels was evaluated. Lining would involve placement and anchoring of an impermeable material on the bottom of the ditch to prevent the water-rock contact. This approach has not been tested but it may be less effective than piping because it only addresses the issues of contact between flowing mine water and underlying rock, whereas piping should isolate mine water from the surrounding mine workings, as well as the underlying rock. In addition, sediment could likely accumulate in the lined channel over time and defeat the purpose of the lining. For these reasons, channel lining is not considered for evaluation as a potential water quality control measure for Brushy Creek Mine.

3.1.3 Work Area Isolation

As described in the Master Underground Water Management Plan, work area isolation includes “isolating or compartmentalizing those areas to prevent the migration of materials into the water conveyance system.” The master plan suggests work areas may be separated from the remainder of the mine by physical measures such as berms, entrance tunnel modifications, or preplanning of new mine area configurations.

The feasibility of these potential measures was discussed with mine personnel. The challenge to implementing these measures is that they will interfere with mining operations. For example, berms placed between drilling or ore loading areas and water drainage channels will interfere with the passage of vehicles. It is impractical to build the berms up and tear them down every time a vehicle or piece of machinery needs to leave the work area. Entrance tunnel modifications and new mine area pre-planning involve designing tunnels so that a high point exists between work areas and the rest of the mine to prevent the drainage of water impacted by mining activities from leaving the work area. This technique is impractical in most cases because the prevention of mine water drainage from work areas will result in flooding of those work areas. For the reasons discussed above, work area isolation is not considered for further evaluation as a possible water quality control measure for Brushy Creek Mine.

3.1.4 Capture of Drill Fines

The Master Underground Water Management Plan also identified the capture of drill fines as a potential control measure. As stated in the Master Underground Water Management Plan, drilling is conducted for both mine development and ore recovery operations and the drilling process produces fines which have the potential to become suspended in mine water. Three types of drilling are used at Brushy Creek Mine:

- Jackhammer drilling is a percussion drilling method used for exploratory drilling in the mine. This is a “wet” drilling technique that generates fine material from the borehole that is carried away from the borehole by water.
- Core drilling is a second exploratory drilling technique that uses water to flush fines away from the core barrel and bit to extract a rock core from the borehole. Drill fines are generated during drilling and carried from the borehole by water.
- Production drilling is a percussion drilling method used during mining operations that can be either air mist or water cooled. Fines are generated in the borehole and carried out of the borehole by water or air.

In general, the quantity of fine materials generated during drilling is relatively small and the water generated during wet drilling is very small relative to other sources of flow in the mine. It is generally infeasible to capture drill fines from any of the above techniques because any method used to capture these fines would substantially interfere with drilling operations. For these reasons, capture of drill fines is not considered for further evaluation as a possible water quality control measure for Brushy Creek Mine.

3.2 TREATMENT MEASURES

One type of underground water control measure considered for improving mine water quality is to actually treat the mine water below ground. Treatment processes that may have the potential to improve the quality of mine water include clarification (settling) and filtration.

3.2.1 Clarification

Clarification is a treatment process that involves the removal of suspended solids from water by gravity settling. Simple clarification typically involves the use of basins or sumps that reduce the velocity of flowing water, which allows a portion of suspended solids to settle. Enhanced clarification usually involves the addition of chemicals to facilitate coagulation and flocculation of fine particles that will not settle on their own. These processes are described below:

- Coagulation is the process of adding chemicals to neutralize particle charges that keep particles dispersed. Once the charges of fine particles are neutralized, they will bind together more readily, forming larger particles. This process is often used when very fine particles are suspended.

- Flocculation is the process of providing suitable conditions for fine particles to bind together and often involves very gentle mixing.

Simple clarification is practiced in the Brushy Creek Mine, in the form of mine water sumps. These sumps are located throughout the mine and act as settling basins. Simple clarification in the form of mine water sumps will be part of the overall mine water management plan for Brushy Creek Mine.

Enhanced clarification using chemicals for coagulation/flocculation, on the other hand, can be a complex process, requiring careful monitoring, with addition of chemicals to adjust the pH of the water being treated for optimization of treatment, followed by readjustment of pH. The process of enhanced clarification results in residuals that are much more difficult to handle and dewater than simple clarification. Providing suitable conditions for settling of the flocculated solids typically requires specialized clarifiers. The challenges of this more complex form of water treatment underground are discussed in Section 3.2.3.

3.2.2 Filtration

Filtration refers to the process of physically separating suspended solids from water by passing the water through material that has openings finer than the suspended materials. This can be accomplished using granular filter materials (e.g., sand filters), woven fabrics, or fabricated plastic or metals filters. The advantage of filtration over clarification is that it results in a more complete separation of water and solids, with the residual solids having lower water content than the residuals of clarification.

Filtration of mine water can potentially be accomplished underground in two ways. First, filters can be used between water sources and water conveyances to remove suspended solids nearer the source. Second, filtration could be used as a centralized treatment process, immediately prior to pumping of mine water to the surface. The use of filtration between water sources and conveyance systems may have potential underground and may be part of the underground water management plan at Brushy Creek Mine. Examples of this are the use of sand berms between flowing coreholes and water collection areas, and filter fabric wrapped around perforated HDPE drainage piping along roadways. Centralized filtration of mine water faces similar challenges as other centralized water treatment processes underground, which are discussed in the following section.

3.2.3 Overall Assessment of Underground Mine Water Treatment Feasibility

Mine water treatment processes, such as filtration between water sources, may be feasible treatment practices for mine water underground. Still, further evaluation is needed to determine the impact of these practices on mine water quality and whether or not they are cost effective. Clarification by means of a centralized mine water sump is currently used at Brushy Creek Mine and will continue to be a part of the overall water management plan. However, other forms of centralized (i.e., large-scale) underground mine water treatment present several challenges, including:

- Available space – Centralized treatment will require a substantial amount of space in the mine. While space is often readily available at the surface, it must be created in the mine by excavating rock. Areas where mining has already occurred are not good candidates because of the possibility that Doe Run may want to return in the future and extract pillars. New areas are expensive to create; the estimated cost of excavating rock underground is $0.60 per cubic foot (c.f.). In order to build only a sump, approximately a half million cubic feet of rock would need to be excavated, and that only includes the space needed to contain the water. In addition, because the same equipment and personnel would be used to excavate the area for treatment as would be used for mining, there is a cost in lost ore production.

- Protection of treatment processes – It would be difficult to prevent treatment processes from being exposed to airborne dust in the mine, which could cause additional metals loading to the treatment system or otherwise upset the processes.

- Specialized operators – The types of treatment that would be required to reduce metals in mine water, aside from simple settling, would likely require trained operators. Such personnel are not currently deployed underground by Doe Run and their deployment underground would be more costly than above ground.

- Management of residuals – One of the biggest challenges for underground mine water treatment is the management of residuals. Although settled materials can be managed using conventional construction equipment, materials settled by flocculation have higher water content and would likely require specialized equipment. In addition, because they are flowable, they would require larger areas for disposal (i.e., they cannot be piled).

The use of mine water sumps for clarification (both distributed throughout the mine and at centralized locations prior to pumping to surface) will be part of the underground water management plan for Brushy Creek Mine. Other types of centralized underground mine water treatment do not appear to be feasible at Brushy Creek Mine because of the challenges outlined above and will not be evaluated further.

3.3 GROUNDWATER INTERCEPTION

Groundwater interception is used here to include all measures that prevent water from entering the mine. Water can enter mine areas in a few ways:

- Coreholes – This refers to exploratory borings advanced from the surface to mine depth or from within the mine into the mine face, used to identify ore locations and direct mining activities. Coreholes sometimes intercept fractures and voids in the rock that convey water and then act as drains to allow water from the rock to enter the mine. To date, this has not been a significant source of water entering Brushy Creek Mine.

- Access and vent shafts – These are large-diameter shafts constructed from the surface to mine depth to allow access by personnel and equipment, removal of ore, and ventilation of mine areas. Because they intercept overlying aquifers and penetrate aquitards between the overlying aquifers and the mine, they can become major water sources to the mine. Casing is usually installed in these shafts, which greatly reduces flows. Flows into these shafts can also come from storm water at the surface, although this contribution is relatively small compared to other flows.
- Fractures – Rock fractures are naturally occurring and mining activities at Brushy Creek occur in an aquifer to begin with, so it is common for those mining activities to intersect water-bearing fractures. When this occurs, the fractures become a means of water entry into the mine.

The primary methods available to intercept groundwater before it enters the mine are sealing of coreholes and fractures, casing of shafts, and aquifer dewatering to prevent groundwater from entering coreholes, shafts, and fractures.

3.3.1 Corehole and Fracture Sealing

When mining operations intersect coreholes and fractures, they can become a source of water to the mine. This can be true for a surface corehole if the corehole was incompletely sealed after drilling or if the seal has somehow failed over time. The Doe Run standard operating procedure for exploratory coreholes requires that coreholes penetrating the Davis shale must be fitted with an expandable packer within the bottom part of the formation and the hole must be filled with grout to at least 50 feet above the top of the Davis formation. This standard operating procedure remains in effect.

If a leaking corehole is encountered during mining operations, the corehole can sometimes be sealed using mechanical packers or grout. Mechanical packers have historically been used and have been shown to be effective, although in some cases stopping the flow from a corehole has caused the flow to enter the mine elsewhere. Brushy Creek Mine personnel may plug coreholes that yield significant flow when they are encountered during mining, however, this has not been necessary in recent years because most coreholes encountered at the Brushy Creek Mine do not have significant flows. In general, mostly at other mines, Doe Run has been evaluating the use of chemical grouts. Two types of chemical grout have been tested at the Fletcher Mine with limited results:

- Two-part grout: This is a two-component grout sold under the trade name H2OSTOP and it has been used for high-inflow coreholes. The grout reacts and sets within seconds of mixing, which is accomplished during injection by a static mixer inside a packer that is inserted in the corehole. The grout can expand in volume up to 20:1 and costs about $195 per cubic foot.
- Moisture-reactive grout: This is a single component grout sold under the trade name Hyperflex that sets in contact with water and is used for lower flow applications. This grout can also expand in volume up to 20:1 and costs about $397 per cubic foot.

These grouts can be effective for sealing fractures as well. Vendor information for both of these products is included in Appendix B. There is no reliable way to estimate how much material will be required to grout a corehole. In the last year, an estimated 200 cubic feet of product has been used. Corehole and fracture sealing will be a part of the underground water management plan for Brushy Creek Mine, where it is feasible, technically possible, and cost-effective to do so. However, at this time there is not a significant need for this activity because, as stated above, most coreholes encountered at the Brushy Creek Mine do not have significant flows.

3.3.2 Shaft Sealing/Repair

Because access and ventilation shafts are necessary for the safe and productive operation of the mine, they cannot be eliminated. Although it is not possible to completely seal the shaft to prevent any water from entering the shaft (and therefore the mine), the standard practices employed by Doe Run are usually capable of eliminating most of the flow. These practices involve the installation of casings in the shafts to seal out water. At present, the shafts at Brushy Creek Mine are not a major source of mine water flow. Therefore, shaft sealing/repair is not considered for further evaluation as a possible water quality control measure for Brushy Creek Mine.

3.3.3 Aquifer Dewatering

The only other potential flow reduction measure to prevent water from entering the mine is interception of the groundwater in the aquifer before it reaches the mine. This would require installation of dewatering wells at critical points around the mine, at the depth of the contributing aquifers, and pumping of groundwater from the wells. Implementation of aquifer dewatering is a substantial and costly undertaking that would typically only be evaluated for very large sources of flow. Aquifer dewatering would require the following steps:

- Hydrogeological investigation to fully characterize water-bearing units around and above the mine.
- Installation of pumping wells to test the rates at which water could be pumped from the aquifer and the drawdowns in potentiometric surface that could be achieved.
- Evaluation of the ability of pumped groundwater to meet surface water discharge limits.
- Upon completion of the above testing, the dewatering system would be designed and constructed.

One major advantage of this approach is that it involves pumping of groundwater to the surface before it comes into contact with the mine workings. This would presumably eliminate the need for treatment at the surface prior to discharge. It is likely not feasible, however, to use aquifer dewatering for an entire mine, miles in length, due to the costs involved, therefore, aquifer dewatering is not considered for further evaluation as a possible water quality control measure for Brushy Creek Mine.

3.4 BEST MANAGEMENT PRACTICES

There are several underground water management practices that can potentially be used to maintain or improve mine water quality. These are referred to as best management practices (BMPs) and several were identified in the Master Underground Water Management plan, including the following:

- Berms
- Channels
- Collection and Containment of Impacted Water
- Clean Mining Areas
- Material Handling and Storage
- Erosion Control
- Roadway Maintenance
- Maintenance Schedules

In addition, sump cleaning and inspections were identified as BMPs that should be considered. These BMPs are discussed below.

3.4.1 Berms

The use of berms was discussed previously in this plan (Section 3.1.3). Because even temporary berms will interfere with the movement of vehicles and equipment in the mine, where working space is already limited, it does not appear that their use is feasible, except in situations where flows can be directed to inactive mining areas, which is already done at Brushy Creek Mine.

3.4.2 Channels

Shallow channels are already used throughout Brushy Creek Mine to convey mine water flows. As discussed in Section 3.1.2, these channels are already problematic because they expose mine water to more impacts from mine workings. The potential for replacing open channels with enclosed pipes will be discussed in Section 4.

3.4.3 Collection and Containment of Impacted Water

Once water is impacted by exposure to mine workings, it should be isolated from unimpacted water. For example, if impacted water is created at the working mine face during ore extraction operations, it should not be mixed with unimpacted water seeping from coreholes, if this can be avoided.

3.4.4 Clean Mining Areas

In general, maintaining clean mining areas may help reduce the potential for mining activities to impact mine water. This “good housekeeping” practice will be employed to the extent possible in all mining areas and may include storage of ore, drill fines, waste rock, and mining equipment away from areas where water is collected.

3.4.5 Material Handling and Storage

This BMP refers to practices for handling and storage of materials that have the potential to impact mine water quality. This may include stockpiled ore or it may include solids removed from sumps during mucking. The practice for storing such material stockpiles will be that they are placed so as to minimize impacts to mine water.

3.4.6 Erosion Control

As described in the Master Underground Water Management Plan, erosion control in mines includes the protection of any surface that has the potential to erode and increase the loading of suspended solids. These areas include material storage piles and transportation corridors. At Brushy Creek Mine, erosion control of storage piles will be addressed by material handling and storage practices and erosion control of transportation corridors will be addressed to the extent feasible by the roadway maintenance program.

3.4.7 Roadway Maintenance

The heavy traffic of trucks and mining equipment over mine roadways, which are normally constructed of crushed rock, can result in erosion of the road surface. This can have two related impacts on mine water quality. First, the erosion of road materials can move fine materials into roadside channels filled with water. Second, the erosion can result in a lowering of the road bed over time, which can eventually lead to flooding of the eroded part of the road. Regular inspection of roadways and prompt repair of eroded areas will be part of the underground water management plan for Brushy Creek Mine.

3.4.8 Maintenance Schedules

Scheduling of maintenance activities related to underground water management at Brushy Creek Mine will be driven by monitoring and inspection activities, as discussed in Section 4.

3.4.9 Sump Cleaning

At Brushy Creek Mine, like all Doe Run mines, mine water flows via gravity and/or pumping to central sumps where it is then pumped to the surface. At Brushy Creek Mine, one main mine water sump is currently used.

All mine water sumps provide temporary storage for mine water and, as a result, can have potential for settling solids, proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids, by design. This means, however, that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, accumulated solids could eventually impair pumping. For these reasons, periodic maintenance of the sumps is required to remove solids. The process of sump cleaning is referred to as “sump mucking”.

Sump mucking involves temporarily draining the sump, then mechanically removing the accumulated solids from the sump. The solids are transported to an inactive area of the mine for storage, where they dewater by gravity drainage. Since they consist of fine rock and ore, the dewatered solids are sometimes added to the mined materials sent to the surface for processing.

Experience at Doe Run mines shows that sump cleaning results in excessive wear on the machinery that is used to remove the accumulated solids because the fine solids get into the mechanical and hydraulic components of the machinery and are abrasive. Significant costs can be incurred for equipment refurbishment after every sump mucking event. Because sump cleaning is a necessary component of mine operations, it will be continued in the future and is discussed further in Section 4.

3.4.10 Inspections

Regular inspection of mine water management measures will be an important part of the overall underground water management plan at Brushy Creek Mine. These inspections will be used to monitor effectiveness of the plan and to identify the need for maintenance of roadways, piping, sumps, and other mine water management measures.

3.5 SUMMARY OF WATER MANAGEMENT MEASURE EVALUATION

Several potential water management measures have been identified for the Brushy Creek Mine as they may have the potential to reduce mine water flows and improve water quality. The measures are summarized in Table 3-1 along with notation on which will be part of the Brushy Creek underground water management plan. In all cases, the use of the measures discussed here will be evaluated and implemented if Doe Run determines that the measures are effective, technically feasible, and cost effective, or will be further evaluated for potential implementation.

Table 3-1. Summary of Water Management Measure Evaluation for the Brushy Creek Mine.

Type of Measure	Measure	Assessment Summary	Included in Brushy Creek UGWMP?
Isolation	Piping	Potentially effective on a localized basis; to be evaluated further	Yes
	Channel lining	Not an effective control measure	No
	Work area isolation	Not feasible	No
	Capture of drill fines	Not feasible	No
Treatment	Clarification	Simple settling feasible; enhanced clarification infeasible	Yes
	Filtration	Potentially feasible on a localized basis; may undergo further evaluation	No
Groundwater Interception	Corehole/fracture sealing	Not currently needed; will be considered on an as-needed basis in the future	No
	Shaft repair/sealing	Not needed	No
	Aquifer dewatering	Not part of plan, pending outcome of investigations at Sweetwater Mine	No
Best management practices (all to undergo regular review and evaluation)	Berms	Useful in some case	Yes
	Channels	Necessary, piping preferred in some areas	Yes
	Collection/ containment	Potentially useful	Yes
	Clean mining areas	Potentially useful	Yes
	Material handling/storage	Potentially useful	Yes
	Erosion control	Addressed by material handling & roadway maintenance	No
	Roadway maintenance	Potentially useful	Yes
	Maintenance schedules	Necessary, driven by monitoring and inspections	Yes
	Sump cleaning	Necessary	Yes
	Inspections	Necessary	Yes

This page is blank to facilitate double sided printing.

4. PLAN ELEMENTS AND IMPLEMENTATION

The underground water management plan for Brushy Creek Mine is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of potential measures focusing on cost-effectiveness and impact on water quality;
- Development of planned actions;
- Implementation of planned actions;
- Monitoring of implemented actions (data collection and inspection);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Brushy Creek Mine plan discussed in this section are:

- Water management actions
- Best management practices
- Monitoring
- Inspection
- Recordkeeping
- Training
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections. It should be noted that mine water treatment evaluations are ongoing at Doe Run. The outcome of these evaluations will determine the most effective mine water treatment method, as well as an accurate estimate of the unit cost for mine water treatment. This will allow evaluation of potential underground water control measures in the context of relative cost-effectiveness, compared to treatment at the surface. Based on these comparisons, some of the measures discussed in this section may be determined not to be cost effective and may be removed from the plan in the future.

4.1 WATER MANAGEMENT ACTIONS

Based on the review of mine data discussed in Section 2 and the evaluation of potential control measures discussed in Section 3, existing practices, procedures, and planned projects are generally appropriate for underground water management at

Brushy Creek Mine. In addition, two contingency plans will be set up for the Brushy Creek Mine to address future potential opportunities for water management actions: corehole sealing contingency and piping contingency. These are described below.

4.1.1 Corehole Sealing Contingency Program

Coreholes do not currently contribute the majority of influent mine water at Brushy Creek Mine, although some coreholes have been found to contribute significant flows. The road rock hole, for example, is estimated to yield approximately 30 gpm of incoming mine water. However, the road rock hole is occasionally used to load aggregate into the mine for road maintenance and cannot be sealed. Another corehole at location B11 was found to contribute approximately 260 gpm of incoming flow and was sealed by Doe Run in 2010.

Because other flowing coreholes may be encountered as mining proceeds, a corehole sealing contingency program will be implemented. This contingency program will include a standard operating procedure and decision framework for determining which coreholes will be sealed. New coreholes that are encountered during mining operations and that produce significant flows to the mine may be sealed, if sealing is technically possible and cost-effective. If possible, the following procedure will be followed:

- Flowrate from the corehole will be estimated by measuring the time required to fill a 55-gallon drum or other similarly-sized container of known volume. If it is not possible to measure the flowrate from the corehole in this manner due to the location of the corehole and difficulty in positioning the container under the stream of flow, a 5-gallon bucket or similar smaller container shall be used. If this is also impractical due to the very small quantity of flow or for safety reasons, the underground water management team will discuss alternate flow estimation methods. Because flows from newly encountered coreholes sometimes vary, the flow will be measured once a month for three months.
- The diameter of the corehole will be measured to the nearest inch. If it is impossible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.
- After measuring the flow and the corehole diameter, the underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past. If the underground water management team is not certain whether sealing is feasible, they will consult with manufacturer’s representatives for mechanical plugs and grouts to help determine the feasibility of sealing the corehole.
- If it is determined that the corehole can be sealed, the underground water management team will determine a schedule for sealing that takes into account the priority of the action relative to other water management measures.

The above process is documented in the form of a standard operating procedure, included in Appendix C. Corehole sealing will be documented in writing. The methods and procedures used for sealing will be documented, along with problems encountered and apparent success of the sealing, for future reference.

4.1.2 Piping Program

During the first plan year, installation of piping from the 9UC Discharge location to the south mine sump is planned. When this piping project is completed, mine water from 9UC will be piped nearly continuously from its source to the south mine sump, where it is pumped to the surface. Water quality will be monitored to evaluate whether water quality is protected by this piping project. Appropriate monitoring locations will be identified as the project is implemented and the data will be discussed in the next version of this plan.

No other piping projects are currently planned for the Brushy Creek Mine for the sole purpose of addressing water quality. However, future circumstances may warrant consideration of piping to address water quality, so a contingency program for piping will be maintained as part of this plan.

Data collected at Doe Run mines indicate that the quality of mine water entering mines can be degraded within a short distance of the point of entry. Therefore, before piping to maintain water quality, the underground water management team will continue to determine whether the piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation. This will likely be accomplished by containing the water at the point of entry with a sump or other system and piping directly from the sump to a main mine water sump.

If the source of the incoming water is a corehole, the procedures outlined in Section 4.1.1 will be followed before piping is evaluated. If the source of the water is a corehole that cannot be sealed, the underground water management team will use the following protocol to determine whether piping will be installed:

- The physical setting and surroundings of the source will be assessed by the underground water management team to identify options for containing the incoming flow as close to its source as possible. This process will consider quantity of flow, space availability, accessibility of the source, other mine operations, cost, and safety.
- Once the most feasible and cost-effective option for containing the flow is determined, the underground water management team will determine the flow path the water will follow to reach the containment area. Water samples will then be collected at the end of that flow path, at the point where water would enter the containment area, as well as the point of entry to the mine (i.e., the corehole, fracture, or shaft). This water sampling will follow the standard procedures for sampling that are currently in place for water sample collection.
- The sampling results will be compared to the results for the incoming water as a measure of the water quality degradation that will occur along the flow path to the location of the containment. The results will also be compared to

water quality data from the mine water sump to which the water would be piped. The underground water management team will use these comparisons to determine whether the piping is likely to provide a significant water quality benefit and whether the piping is cost-effective.

All data collected during piping evaluations will be recorded. Upon review of new data in the future, if a piping project is determined to be ineffective, the piping project may be terminated or, if already installed, the piping may be removed for use elsewhere.

4.1.3 Ongoing Water Management Measure Evaluations

In addition to the corehole sealing and piping contingency programs described above, the following additional actions will be considered on an as-needed basis:

- Additional piping – As mine expansion occurs, significant inflows of relatively clean groundwater may be encountered and, in some cases, it may be feasible and cost-effective to contain the water locally and pipe it directly to mine water sumps. This measure will be evaluated by the water management team on a case-by-case basis.
- New corehole sealing techniques/materials – The water management team will continue to evaluate new techniques or materials for corehole sealing, as they become available.
- New mine water pump shafts – As mining operations progress, it may become feasible to construct new pump shafts to the surface, as an alternative to moving water from newly mined areas to existing mine water sumps. This will be evaluated by the water management team on an as-needed basis.
- Mine expansion – During mine expansion activities, mine personnel will consider water management strategies from a water quality, as well as logistical, perspective and identify environmentally-appropriate water management strategies into the expansion design.

As with the planned activities described in the preceding section, control measure evaluations will be documented in future updates to this plan.

In addition to the contingency actions outlined above, best management practices, as described in Section 4.2, will be used to manage water quality.

4.2 BEST MANAGEMENT PRACTICES

Several BMPs will be implemented at Brushy Creek Mine as part of this plan, as described in the following sections. Some of these BMPs, such as berms, channels, collection, and clean mining areas will likely be used relatively infrequently because of their limited applicability. Others, such as roadway maintenance and sump cleaning will be performed more frequently, but still on an as-needed basis. BMPs and the conditions where they may be useful will be discussed during personnel training.

4.2.1 Berms

Berms are low barriers used to direct flowing water in a desired direction, away from its natural course. Although the use of berms to contain water within work areas is infeasible due to interference with mining activities, as described in Section 3.1.3, berms may be useful in areas of the mine where active mining and hauling is not occurring. Berms be considered a potential water management practice in areas where they will not interfere with mining.

4.2.2 Channels

Channels are shallow watercourses, usually along roadways, in the mine. Although allowing water to flow uncovered in channels has been identified as a source of water quality degradation, there may be situations where construction of channels will be useful. For example, as with berms described above, channels may be useful in diverting flow away from main mine water sumps towards unused or inactive areas of the mine. In such situations, a simple open channel might be used or a combination of channel and pipe may be used, where the diverted flow has to cross a roadway.

4.2.3 Collection/Containment

Collection or containment may be used, where feasible and cost-effective, in situations where water impacted by mining activities is in proximity to sources of relatively unimpacted water. Possible collection/containment techniques may include:

- Construction of a local sump to collect the impacted mine water or the unimpacted water source for pumping.
- Use of diversion channels or berms to direct the flow of impacted mine water away from the source of unimpacted water.

The appropriate method of collection or containment will be determined on a case-by-case basis. In situations where the unimpacted water source is a newly discovered corehole, the procedure for evaluating corehole sealing will be followed.

4.2.4 Clean Mining Areas/Material Handling and Storage

The ‘Clean Mining Areas’ and ‘Material Handling and Storage’ BMPs discussed in Sections 3.4.4 and 3.4.5 are combined here because they are closely related. This combined BMP refers to maintaining work areas in the vicinity of open mine water in such a way as to minimize the potential for water quality degradation. This is especially relevant to areas around sumps and around channels that have not been piped. Where possible, stockpiled materials such as ore and waste rock should be located to minimize impacts to water. Equipment should also be stored away from water where possible.

4.2.5 Roadway Maintenance

Roadways will be inspected on a regular basis by mine supervision personnel and any significant repairs will be documented. These inspections will be specifically directed at identifying roadway conditions that might contribute to water quality degradation including, but not necessarily limited to, the following:

- eroded sections of the roadway that are likely to contribute to the degradation of mine water quality (repaired by filling to an acceptable grade)
- broken or plugged drain pipes (repaired by replacing broken pipe or clearing plug)
- water entering from the back and falling onto the road causing erosion (repaired by suspended curtains of suitable material over the roadway to divert falling water to ditches)

It should be noted that there may be cases where a low point in a roadway exists because it is the low point of the mine tunnel and not necessarily due to erosion. In such cases, filling may create insufficient clearance between passing trucks and the back, so repair is not feasible. When appropriate, significant problems and repairs will be logged in the Doe Run Enterprise Task Management System (ETMS).

4.2.6 Maintenance Schedules

Maintenance related to underground water management at Brushy Creek Mine will be performed on an as-needed basis. Regularly scheduled inspections may identify additional maintenance needs.

4.2.7 Sump Cleaning

Brushy Creek Mine has two main mine water sumps, located adjacent to each other, referred to as the North Sump and the South Sump. Both sumps were recently cleaned: the South Sump was cleaned in July 2012 and the North Sump was cleaned in August 2012. As with other Doe Run mines, the Brushy Creek Mine sumps will be inspected quarterly as part of the routine water management inspection program at Brushy Creek Mine.

If it is logistically feasible, the main mine water sumps at Brushy Creek Mine will be equipped with a sonar depth finder capable of measuring the depth to the sediment/water interface. If this equipment can be installed, a decrease in water depth of 50% at a point in close proximity to the pumps will be used to trigger sump cleanout. This level of fill is based on the experience of mine personnel. As described below, the main mine water sump will be sampled on a regular basis and these data will be evaluated along with the level of accumulated sediment to determine whether a different level should be used to trigger sump cleaning. A standard operating procedure for monitoring sediment levels in main mine water sumps is included in Appendix C.

4.3 MONITORING

Ongoing underground water quality monitoring will be continued at the Brushy Creek Mine to improve the understanding of mine water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 4-1 will be sampled, unless it is determined by Doe Run that an adequate amount of data has been collected.

Table 4-1. Underground Water Sampling Locations for the Brushy Creek Mine.

Location	Sample ID Previously Used	Rationale
Mine water from north mine	BC-NMNSPDITCH	Monitor water quality entering north sump from north mine
Mine water from southeast mine	BC-SEMNSPDITCH	Monitor water quality entering south sump from southeast mine
Mine water from southwest mine	BC-SWMNSPDITCH	Monitor water quality entering south sump from southwest mine*
Mine water from 9UC piping project	BC-9UCPIPE	Monitor water quality entering south sump from southwest mine
*Water flows in ditch for approximately 300 feet from the pipe to the sump.		

Continued monitoring was initiated in February 2012, and has typically been conducted on a monthly basis. The results of the continued monitoring efforts are presented in Figures 4-1 through 4-5. Evaluation of the most recent data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

In addition to the monitoring regime described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for underground water management at Brushy Creek Mine.

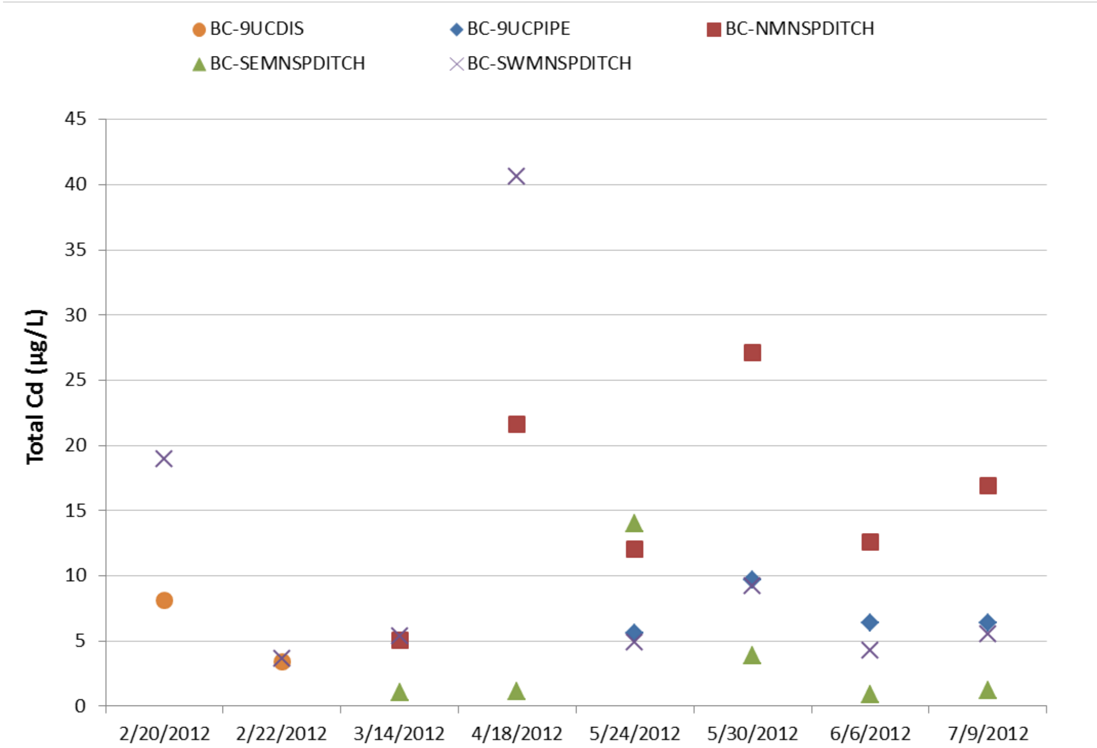


Figure 4-1. Continued Monitoring of Total Cadmium in Underground Sampling Locations at Brushy Creek Mine.

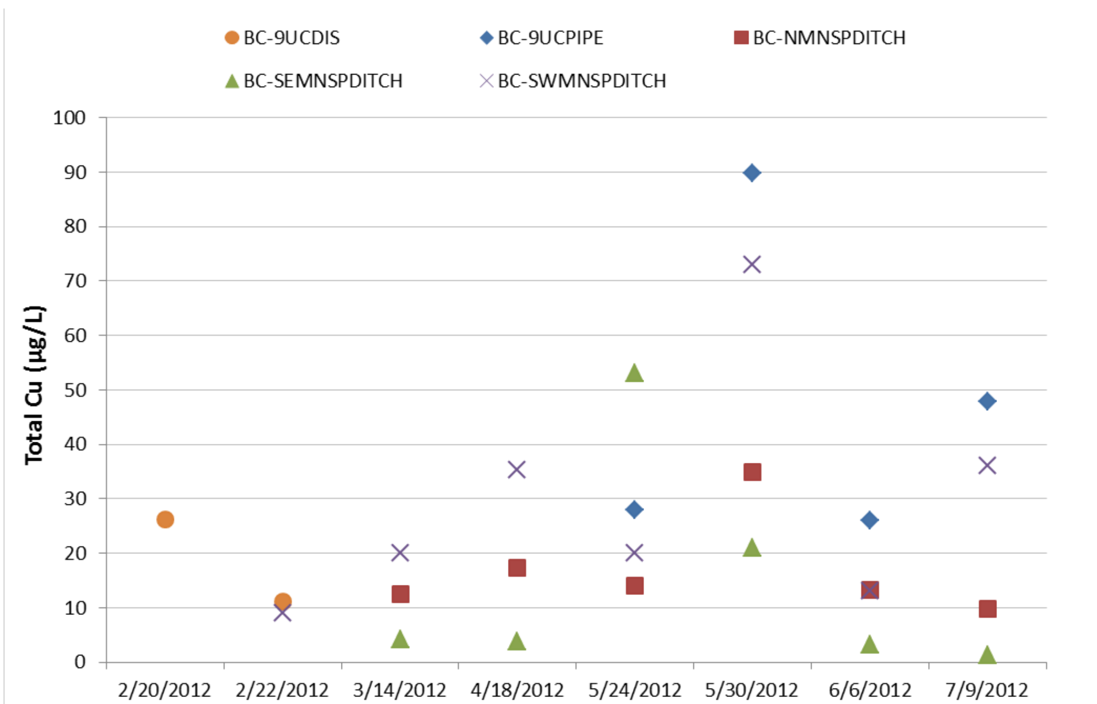


Figure 4-2. Continued Monitoring of Total Copper in Underground Sampling Locations at Brushy Creek Mine.

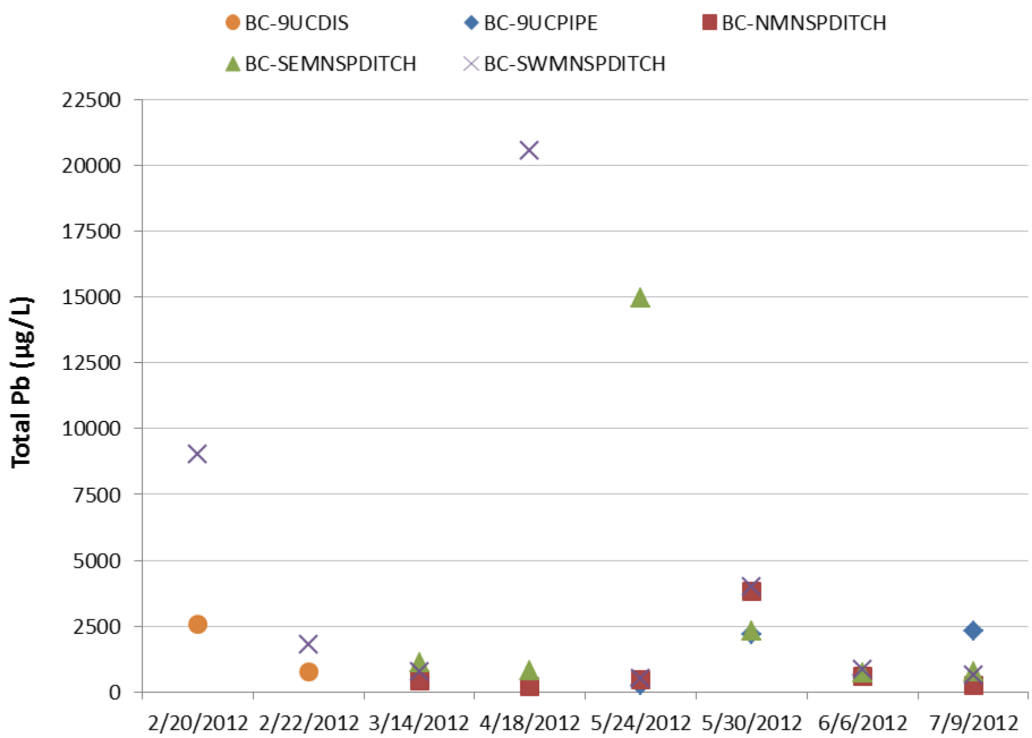


Figure 4-3. Continued Monitoring of Total Lead in Underground Sampling Locations at Brushy Creek Mine.

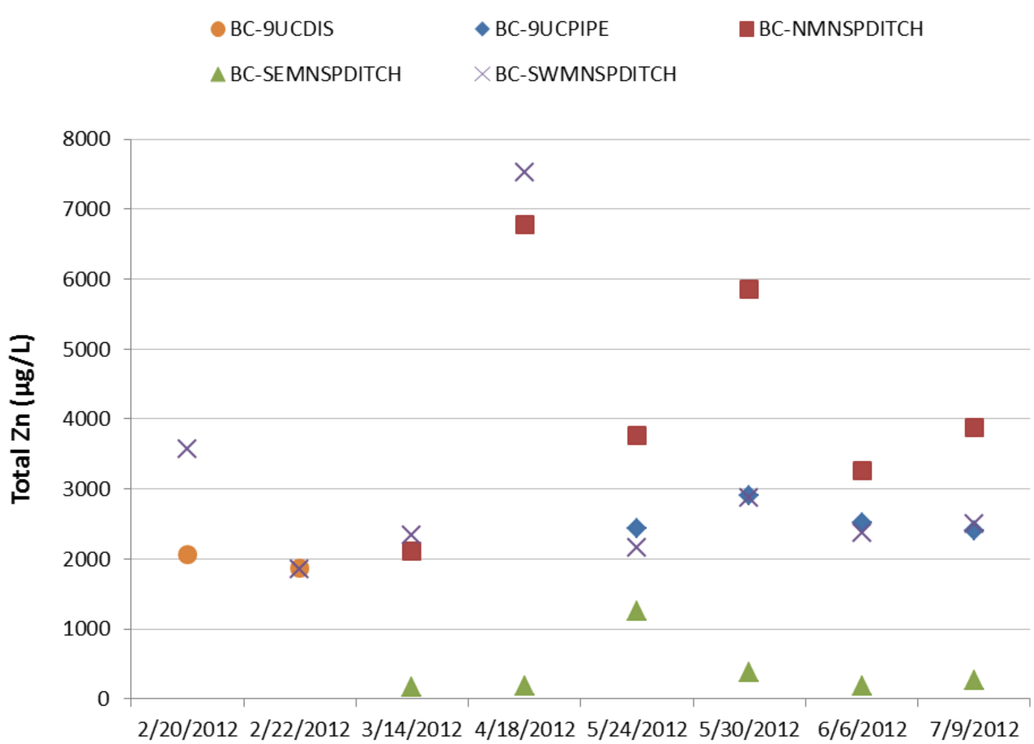


Figure 4-4. Continued Monitoring of Total Zinc in Underground Sampling Locations at Brushy Creek Mine.

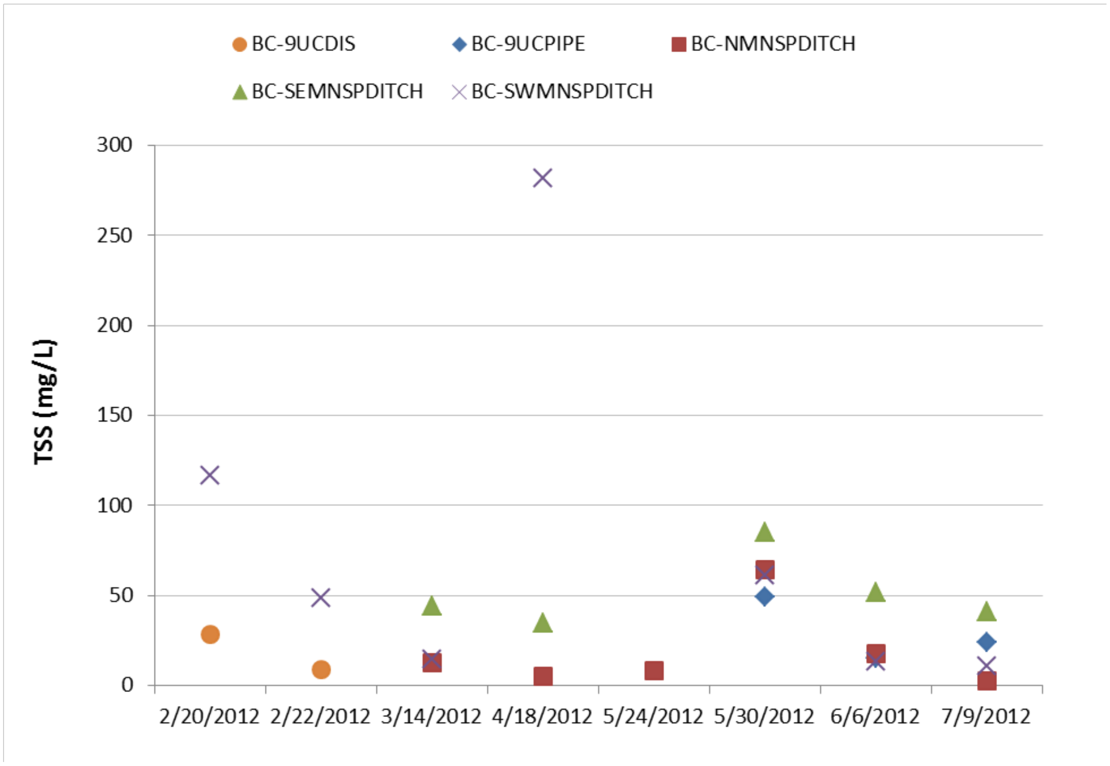


Figure 4-5. Continued Monitoring of Total Suspended Solids in Underground Sampling Locations at Brushy Creek Mine.

4.4 INSPECTIONS

Underground water management inspections will be conducted at Brushy Creek Mine on a quarterly basis to monitor effectiveness of water management measures and to identify the need for maintenance. Inspections will include visual inspection of the following:

- Main mine water sump to visually assess turbidity and general condition;
- Water piping, to identify leaks;
- Roadways, to identify the need for maintenance;
- Material and equipment storage areas to identify the need for improved separation from sources, conveyances, and sumps;
- Coreholes and/or fractures scheduled for sealing between the previous and current inspections, if any, to verify that sealing has occurred and was effective;
- Sources of water identified since the previous inspection; and
- Any other water management actions undertaken since the last inspection.

Inspections will be conducted by trained personnel (see Section 4.5). All inspections will be documented using the form in Appendix D, which will include the name and signature of the person performing the inspection.

4.5 TRAINING

Training was identified in the Master Underground Water Management Plan and will be an important part of the plan for Brushy Creek Mine. Initial training will be provided by April 30, 2012 to all personnel involved in the management of water at Brushy Creek Mine including, but not necessarily limited to:

- Mine supervision
- Mine engineers
- Technical service personnel
- Environmental technicians

In addition to the initial training for these personnel, annual refresher training will be conducted.

The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for underground water management (including the environmental need);
- Best management practices to be used throughout the mine;
- Specific water management actions being implemented or planned;
- Water management protocols and standard operating procedures;
- Inspections;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

4.6 TRACKING/RECORD-KEEPING

Water management measures will be inspected at Brushy Creek Mine quarterly and the inspections will be documented on the form included in Appendix D. These forms will be kept on file on-site by the Brushy Creek Underground Water Manager, Steve Kearns or designee. In addition, all significant water management measures and best management practices implemented at Brushy Creek Mine will be documented in writing and a copy kept on file at the same location. Actions taken, best management practices, inspections, and maintenance of underground water management measures will be recorded in the Doe Run ETMS.

4.7 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between January 1, 2013 and February 28, 2013. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Brushy Creek Mine facility.

4.8 IMPLEMENTATION SCHEDULE

The current schedule for the water management plan implementation is presented in Table 4-2. This schedule is based on the best information available as of the date of this plan.

Table 4-2. Implementation Schedule for First Year Underground Water Management Plan Activities at Brushy Creek Mine.

Action	Mar. 2012	April 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Apr. 2013	Jan. 2014
Training														
Inspections	Once per Calendar Quarter													
Sampling						As needed								
9UC Piping Project														
Plan Review & Update														

5. REFERENCES

LimnoTech. Underground Water Sampling and Analysis Plan Report. August 4, 2011. (LimnoTech, 2011)

Resource Environmental Management Consultants, Inc. *Master Underground Water Management Plan: The Doe Run Company SEMO Operations*. 2010. (RMC, 2010)

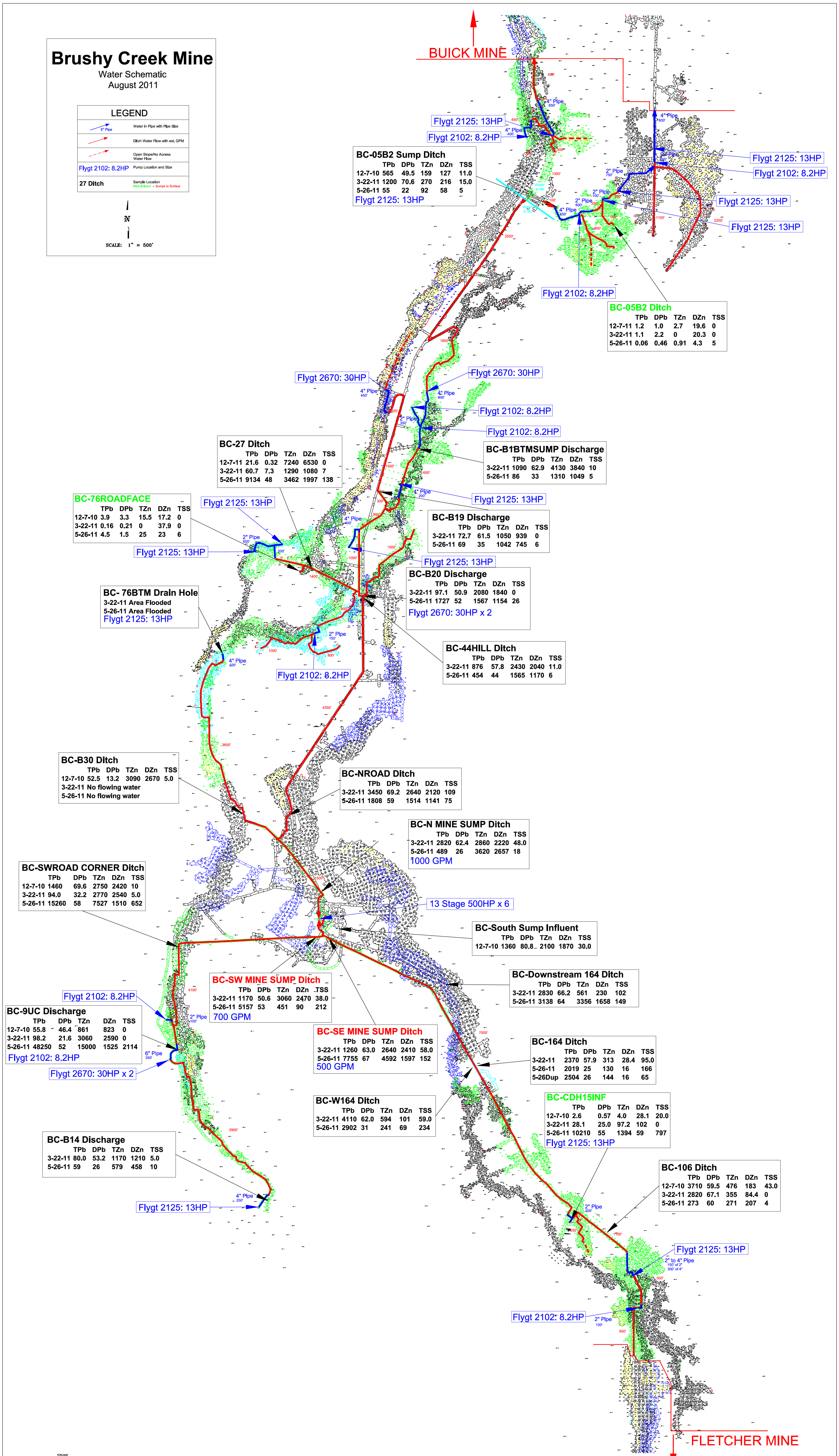
U.S. Geological Survey. "History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict" (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008)

This page is blank to facilitate double sided printing.

APPENDIX A:

BRUSHY CREEK MINE WATER FLOW MAP WITH LEAD AND ZINC SAMPLING RESULTS

This page is blank to facilitate double sided printing.



Brushy Creek Mine
Water Schematic
August 2011
LEGEND
Flygt 2102: 8.2HP
27 Ditch
N
BUICK MINE
FLETCHER MINE
Flygt 2125: 13HP
Flygt 2102: 8.2HP
BC-05B2 Sump Ditch
TPb DPb TZn DZn TSS
12-7-10 565 49.5 159 127 11.0
3-22-11 1200 70.6 270 216 15.0
5-26-11 55 22 92 58 5
Flygt 2125: 13HP
Flygt 2125: 13HP
Flygt 2102: 8.2HP
Flygt 2125: 13HP
Flygt 2125: 13HP
Flygt 2102: 8.2HP
BC-05B2 Ditch
TPb DPb TZn DZn TSS
12-7-11 1.2 1.0 2.7 19.6 0
3-22-11 1.1 2.2 0 20.3 0
5-26-11 0.06 0.46 0.91 4.3 5
Flygt 2670: 30HP
Flygt 2670: 30HP
Flygt 2102: 8.2HP
Flygt 2102: 8.2HP
BC-27 Ditch
TPb DPb TZn DZn TSS
12-7-11 21.6 0.32 7240 6530 0
3-22-11 60.7 7.3 1290 1080 7
5-26-11 9134 48 3462 1997 138
BC-B1BTMSUMP Discharge
TPb DPb TZn DZn TSS
3-22-11 1090 62.9 4130 3840 10
5-26-11 86 33 1310 1049 5
BC-76ROADFACE
TPb DPb TZn DZn TSS
12-7-10 3.9 3.3 15.5 17.2 0
3-22-11 0.16 0.21 0 37.9 0
5-26-11 4.5 1.5 25 23 6
Flygt 2125: 13HP
Flygt 2125: 13HP
BC-B19 Discharge
TPb DPb TZn DZn TSS
3-22-11 72.7 61.5 1050 939 0
5-26-11 69 35 1042 745 6
Flygt 2125: 13HP
Flygt 2125: 13HP
BC-B20 Discharge
TPb DPb TZn DZn TSS
3-22-11 97.1 50.9 2080 1840 0
5-26-11 1727 52 1567 1154 26
Flygt 2670: 30HP x 2
BC- 76BTM Drain Hole
3-22-11 Area Flooded
5-26-11 Area Flooded
Flygt 2125: 13HP
BC-44HILL Ditch
TPb DPb TZn DZn TSS
3-22-11 876 57.8 2430 2040 11.0
5-26-11 454 44 1565 1170 6
Flygt 2102: 8.2HP
BC-B30 Ditch
TPb DPb TZn DZn TSS
12-7-10 52.5 13.2 3090 2670 5.0
3-22-11 No flowing water
5-26-11 No flowing water
BC-NROAD Ditch
TPb DPb TZn DZn TSS
3-22-11 3450 69.2 2640 2120 109
5-26-11 1808 59 1514 1141 75
BC-N MINE SUMP Ditch
TPb DPb TZn DZn TSS
3-22-11 2820 62.4 2860 2220 48.0
5-26-11 489 26 3620 2657 18
1000 GPM
BC-SWROAD CORNER Ditch
TPb DPb TZn DZn TSS
12-7-10 1460 69.6 2750 2420 10
3-22-11 94.0 32.2 2770 2540 5.0
5-26-11 15260 58 7527 1510 652
13 Stage 500HP x 6
BC-South Sump Influent
TPb DPb TZn DZn TSS
12-7-10 1360 80.8 2100 1870 30.0
BC-SW MINE SUMP Ditch
TPb DPb TZn DZn TSS
3-22-11 1170 50.6 3060 2470 38.0
5-26-11 5157 53 451 90 212
700 GPM
BC-Downstream 164 Ditch
TPb DPb TZn DZn TSS
3-22-11 2830 66.2 561 230 102
5-26-11 3138 64 3356 1658 149
Flygt 2102: 8.2HP
BC-9UC Discharge
TPb DPb TZn DZn TSS
12-7-10 55.8 46.4 861 823 0
3-22-11 98.2 21.6 3060 2590 0
5-26-11 48250 52 15000 1525 2114
Flygt 2102: 8.2HP
Flygt 2670: 30HP x 2
BC-SE MINE SUMP Ditch
TPb DPb TZn DZn TSS
3-22-11 1260 63.0 2640 2410 58.0
5-26-11 7755 67 4592 1597 152
500 GPM
BC-164 Ditch
TPb DPb TZn DZn TSS
3-22-11 2370 57.9 313 28.4 95.0
5-26-11 2019 25 130 16 166
5-26Dup 2504 26 144 16 65
BC-W164 Ditch
TPb DPb TZn DZn TSS
3-22-11 4110 62.0 594 101 59.0
5-26-11 2902 31 241 69 234
BC-CDH15INF
TPb DPb TZn DZn TSS
12-7-10 2.6 0.57 4.0 28.1 20.0
3-22-11 28.1 25.0 97.2 102 0
5-26-11 10210 55 1394 59 797
Flygt 2125: 13HP
BC-B14 Discharge
TPb DPb TZn DZn TSS
3-22-11 80.0 53.2 1170 1210 5.0
5-26-11 59 26 579 458 10
Flygt 2125: 13HP
BC-106 Ditch
TPb DPb TZn DZn TSS
12-7-10 3710 59.5 476 183 43.0
3-22-11 2820 67.1 355 84.4 0
5-26-11 273 60 271 207 4
Flygt 2125: 13HP
Flygt 2102: 8.2HP

APPENDIX B:

VENDOR INFORMATION ON GROUT USED FOR COREHOLE SEALING

This page is blank to facilitate double sided printing.

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

HYPERFLEX

Single component, low density, flexible, hydrophobic grout.

Uses

Sealing of water and gasses in mining and civil applications. Reacts with moisture to form a flexible closed cell grout.

Advantages

- **Simple application**
- **Adjustable set time with catalyst**
- **Flexible, absorbs movement**
- **Low expansive pressure**
- **"Self injection" into the finest of fractures**

Packaging

55 Gallon Steel Drums
5 Gallon Plastic Containers
5 Gallon Metal Containers
1 Gallon Metal Containers

Approvals

NSF 61-2007 approved for use with potable water.

Transport

USDOT. Unregulated Class 55

Physical Properties

Density	Free rise	2.25 lbs/ft³
Low temp. aging	Confirmed	
-20° F (shrinkage)	0% 1 Day	ASTM D-2126
Viscosity	4000 cps	ASTM D-2126
Specific Gravity @ 60° F	1-30%	A-Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Compressive	25 psi	ASTM D-1621
Shear	171 psi	ASTM C-273
Tensile	30 psi	ASTM D-1623
Elongation	300%	ASTM D-1623

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture.

Shelf Life

2 year minimum in unopened containers.

Caution: Always read MSDS prior to use.

WWW.Sub-Technichal.com

724 625 0008 VOICE 724 625 0009 Fax

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

STI 03 - 0.03

H20STOP

Dual component, low density, highly reactive, early strength, water control grout

Uses

Water control in mining and civil applications for cessations of high (3,000 G.P.M. +) leaks, combined with rapid void filling and early strength characteristics.

Advantages

- **Extremely fast reacting**
- **Rapid sealing**
- **High early strength**
- **Will inject into the finest of fractures**
- **Will not wash out**

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture. Store under 80 degrees.

Packaging

55 Gallon Steel Drums

Approvals – On file

Transport

USDOT Unregulated Class 55

Shelf Life

2 Year minimum in unopened containers.

Physical Properties

-20º F (shrinkage)	0% 1 day	ASTM D-2126
Viscosity @ 68º F	200 cps A – Side	300 cps B – Side
Specific Gravity @ 60º F	1.23 A - Side	1.04 B - Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Density (Free Rise)	03 PCF	ASTM D-1622
Compressive	200 psi	ASTM D-1621
Tensile	112 psi	ASTM D-638
Shear	107 psi	ASTM D-732

Sub-Technical, Inc.
363 Mars Valencia Road
Mars, Pennsylvania 16046 U.S.A.
Phone: (724)625-0008 Fax: (724)625-0009
www.sub-technical.com
stisales@sub-technical.com

Always Read MSDS Sheets Prior to USE

APPENDIX C:

STANDARD OPERATING PROCEDURES

This page is blank to facilitate double sided printing.

I. INTRODUCTION

Exploration coreholes at the Doe Run Mines are currently sealed by mine personnel. This practice has been in place for many years. New coreholes that are encountered during mining operations and that produce significant flows to the mine will be sealed, if sealing is technically feasible. This standard operating procedure provides a decision framework and guidelines for monitoring and sealing coreholes when they are encountered during mining operations.

II. MATERIALS

The following materials, as required, will be used when coreholes are encountered:

- Any necessary safety equipment;
- 55 gallon drum or other similarly sized container of known volume;
- 5 gallon bucket or similar smaller container;
- Stopwatch;
- Measuring tape;
- Field log;
- Mine map;
- Camera.

III. PROCEDURES / GUIDELINES

When a corehole is encountered during mining operations the following procedures shall be used:

A. Determine flow rate from corehole

1) Flowrate from the corehole will be estimated by measuring the time required to fill a 55 gallon drum or other similarly sized container of known volume.
2) If the location of the corehole prevents the use of a 55 gallon drum or if the flow is too small for filling of a 55-gallon drum to be practical, then a 5 gallon bucket or similar smaller container will be used.
3) If, due to the quantity of flow or for safety reasons, it is not possible to measure the flow, this should be reported to the underground water management team who will determine an alternate flow estimation method.
4) Because flows often change after coreholes are encountered, the flow rate will be measured once per month for three months to obtain a better estimate of its long-term flow.

B. Measure the corehole diameter

1) The diameter of the corehole will be measured to the nearest inch.
2) If it is infeasible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.

C. Determine if sealing is required and feasible

1) If the flow from the corehole exceeds 25 gallons per minute the corehole will be sealed.
2) The underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past.
3) If it is unclear whether sealing is feasible, the underground water management team will consult with manufacturer's representatives for mechanical plugs and grouts to help

determine the feasibility of sealing the corehole.

D. Seal the corehole

If it has been determined that the corehole can be sealed, the underground water management team will determine a schedule for the sealing work and ensure that the work is completed.

E. Documentation

The following information must be recorded in writing and submitted to the underground water manager:

1) Corehole discovery time and date.
2) Location of corehole recorded on map
3) Diameter of corehole
4) Measured flowrate – record procedure and results
5) Determination of sealing requirement
6) Problems encountered with sealing determination
7) Communication with the underground water management team
8) If the corehole cannot be sealed – record the reasons for that determination
9) Methods and procedures of corehole sealing
10) Problems encountered in the sealing process and apparent success
11) Sealing completion time and date.
12) Pictures of the corehole will also be taken and kept with the field log.

I. INTRODUCTION

Mine water sumps provide temporary storage for mine water, which results in the settling of solids proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids. This means that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, the accumulated solids could eventually impede pumping. For these reasons, periodic maintenance of the sumps is required to remove accumulated solids.

The process of sump cleaning is referred to as "sump mucking". This involves draining the sump, then mechanically removing the accumulated solids from the sump. This standard operating procedure provides guidelines for monitoring main mine water sumps and determining the need for sump cleanout.

II. MATERIALS

The following materials will be available to monitor mine sumps:

- Personal protective equipment as required by the Health and Safety Plan;
- Light source;
- Depth finding device;
- Tape measure;
- Field log;

III. PROCEDURES / GUIDELINES

All major mine sumps will be cleaned when the accumulated solids exceed 50% of the water depth in the sump at the point of measurement near the pumps. To determine the sump mucking trigger, the following procedures must be adhered to:

A. Depth Measurement

1) A depth finding sonar device will be installed near the pumps at each of the major mine sumps to measure the depth of sediment in the sump.
2) A standard reference mark will be established for each sump, to which the water level can be referenced on a recurring basis.
3) The water level will be determined by measuring from the standard reference mark down to the water level with a tape measure.
4) As an alternative to steps 2 and 3, mine personnel may opt to install a staff gauge in the sump for measuring water level.

B. Inspection

1) During each quarterly inspection, the water level and depth to solids in each sump will be recorded from depth finding device.

C. Documentation

The following information will be recorded:

1) Sump identification/location
2) Sump inspection date
3) Measurement of water level
4) Measurement of depth to sediment in each sump
5) Notification of underground water management team, if the depth of solids is more than 50% of the water depth in the sump
6) Start and end date for sump cleanout and problems encountered

APPENDIX D:

UNDERGROUND WATER CONTROL MEASURE INSPECTION FORM

This page is blank to facilitate double sided printing.

Underground Water Management Inspection

Date: ________________________ **Inspection By:**_________________________

Mine: ____

Notes: ____

Sumps

Sump ID/Location	Water Level	Depth to Sediment	Notification Date

Notes: ____

____

____

Piping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

Underground Water Management Inspection

Date: ______________________ **Inspection By:**_______________________

Roadways

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

BMPs/General Housekeeping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

EXHIBIT N

UNDERGROUND WATER MANAGEMENT PLAN for the FLETCHER/WEST FORK MINE

Prepared for: **The Doe Run Resources Corporation d/b/a The Doe Run Company**

April 2, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix A: Fletcher/West Fork Mine Water Flow Map with Lead and Zinc Sampling Results
Appendix B: Vendor Information on Grout Used for Corehole Sealing
Appendix C: Standard Operating Procedures
Appendix D: Underground Water Control Measure Inspection Form

1. INTRODUCTION

This document presents the Underground Water Management Plan (UGWMP) for the Fletcher/West Fork Mine, prepared on behalf of the Doe Run Resources Corporation, d/b/a/ The Doe Run Company (DRC or Doe Run). The Fletcher/West Fork UGWMP has been prepared in accordance with the Master UGWMP previously prepared by Resource Environmental Management Consultants, Inc. In keeping with the Master UGWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility.

While the Fletcher and West Fork Mines were historically developed and operated separately, responsibility for mining activities at West Fork has been delegated to Fletcher Mine personnel since 2000. Because planning and management of mining activities for the two mines are currently performed by the same management team at Doe Run, this water management plan was prepared jointly for both Fletcher and West Fork. Although data from each mine is analyzed and discussed separately, management activities discussed in this plan apply to both mines unless stated otherwise. For simplicity, the two mines are referred to as a single entity in this plan (the Fletcher/West Fork Mine), where appropriate. It is important to note, however, that mine water from each mine is pumped to the surface separately, at each respective surface location.

1.1 FACILITY DESCRIPTION

Fletcher/West Fork Mine is located in Reynolds County, Missouri, approximately 27 miles south of Viburnum (Figure 1-1). Brief histories of the facilities are summarized in Tables 1-1 and 1-2.

Table 1-1. History of the Fletcher Mine (USGS, 2008).

Year	Event
1966	St. Joseph Lead Company began drilling mine shaft.
1967	St. Joseph Lead Company began production.
1976	Mine water pond constructed to hold mine water previously stored in tailings pond.
1986	Doe Run acquired St. Joseph Lead Company and took over operation of Fletcher Mine.

Table 1-2. History of the West Fork Mine (USGS, 2008).

Year	Event
1960s	Ore body discovered by Asarco, Inc.
1980s	Deposit developed by Asarco, Inc.
1985	Mine begins production.
1988	Mine reaches full production.
1998	Mine purchased by the Doe Run Company.
2000	Ore processing at West Fork ceases and ore shipment to Fletcher Mill begins.

The Fletcher/West Fork Mine is located south-centrally within the Viburnum Trend. Mining operations occur approximately 1,000 feet below ground surface. The layout of the Fletcher/West Fork Mine is shown in Figures 1-2 and 1-3.

1.2 OBJECTIVES

As stated above, the main objective of this UGWMP is to evaluate the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading to surface waters at the facility. This main objective is met through the following:

- Understanding of the sources, quantity, and movement of water through the mine.
- Understanding of the quality of water entering, moving through, and leaving the mine, with respect to the target constituents of interest.
- Identification and evaluation of potential control measures for reducing water volumes, metals concentrations, or both in the mine.

Each of these items is discussed in this plan. The UGWMP also presents an assessment of the technical feasibility of various potential control measures for the Fletcher/West Fork Mine, as well as a plan for further investigation or implementation of potentially technically feasible control measures, based on whether such measures are likely to reduce metals loading and whether they are cost-effective.

1.3 UNDERGROUND WATER MANAGEMENT TEAM

Underground water management for the Fletcher/West Fork Mine will be the responsibility of the individuals named in Table 1-3.

Table 1-3. Fletcher/West Fork Mine Underground Water Management Team.

Job Title	Name	Contact Information	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	P.O. Box 500 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mine Manager	Greg Sutton	P.O. Box 500 Viburnum, MO 65566 573-626-2001	Oversight and management of Doe Run Mining Operations
Fletcher/West Fork General Mine Supervisor	Gary Henry	230 County Road 849 Centerville, MO 63633 573-689-2251 x 4110	Fletcher/West Fork UGWMP Oversight, Implementation, and Record-Keeping
Fletcher/West Fork Mine Superintendent	Clay McNail	230 County Road 849 Centerville, MO 63633 573-689-2251 x 4131	Fletcher/West Fork UGWMP Secondary Oversight, Implementation, and Record-Keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573-689-4535	Environmental data collection, management, and reporting

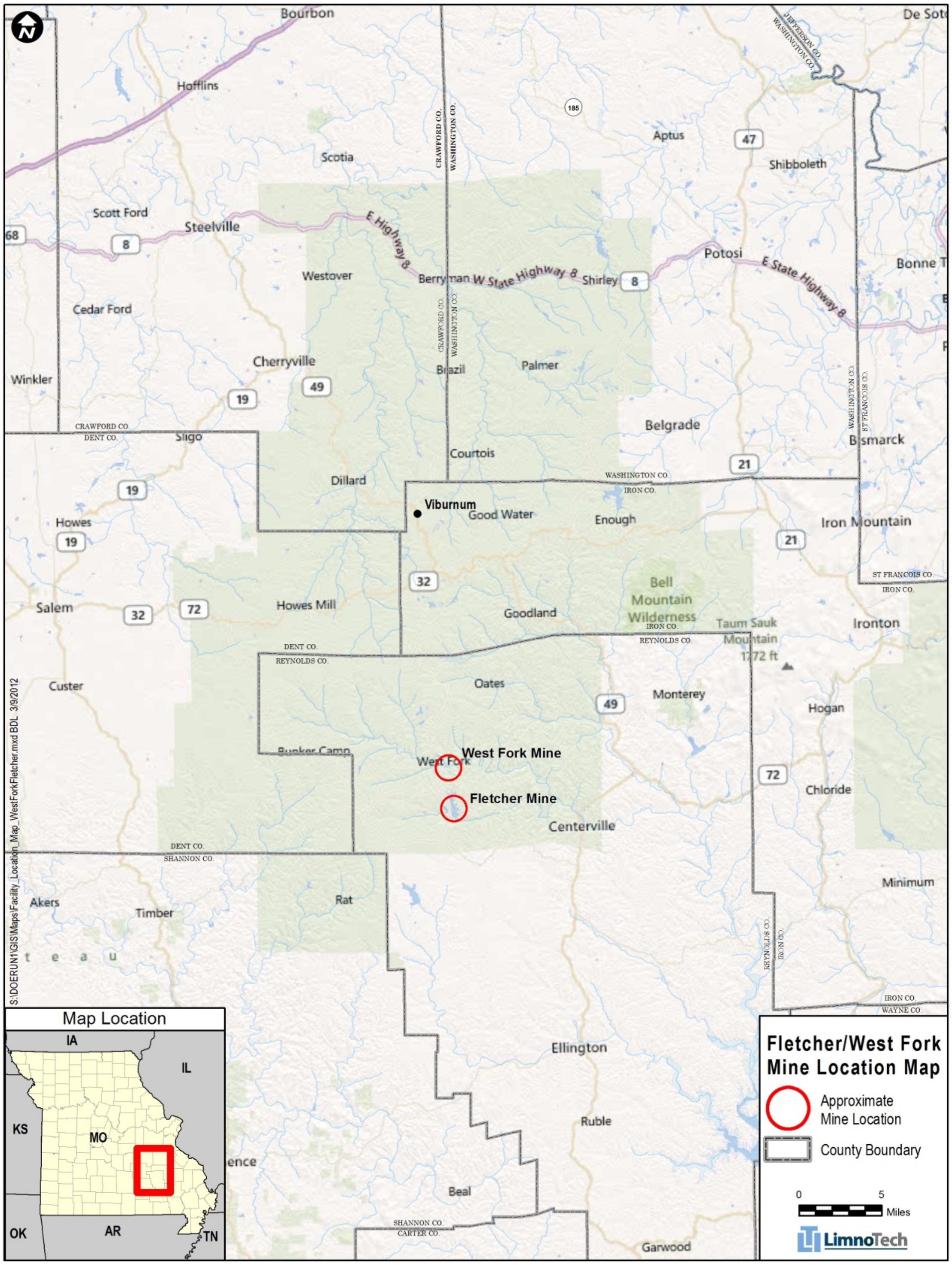


Figure 1-1. Location of the Fletcher/West Fork Mine.

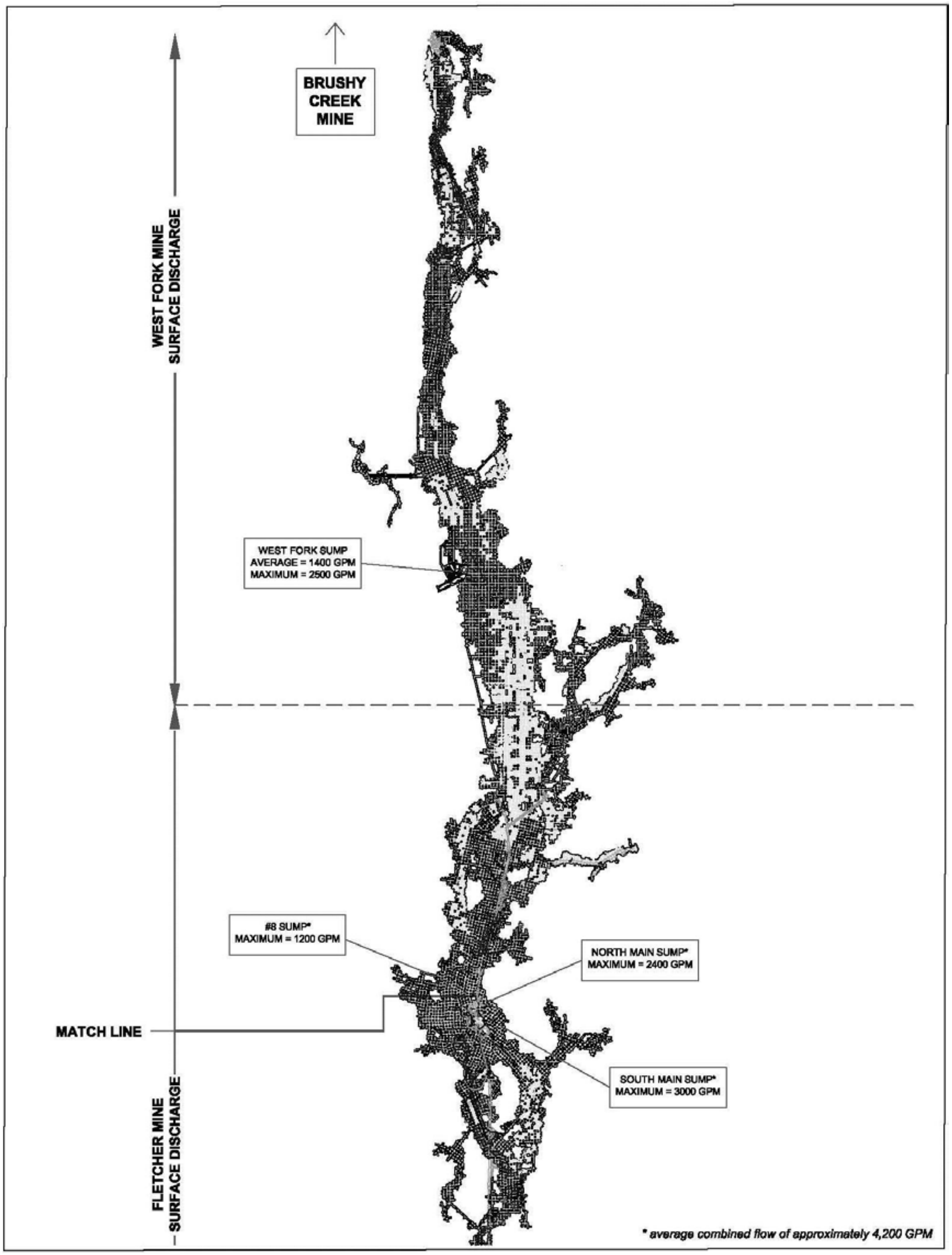


Figure 1-2. Layout of the Fletcher/West Fork Mine - North.

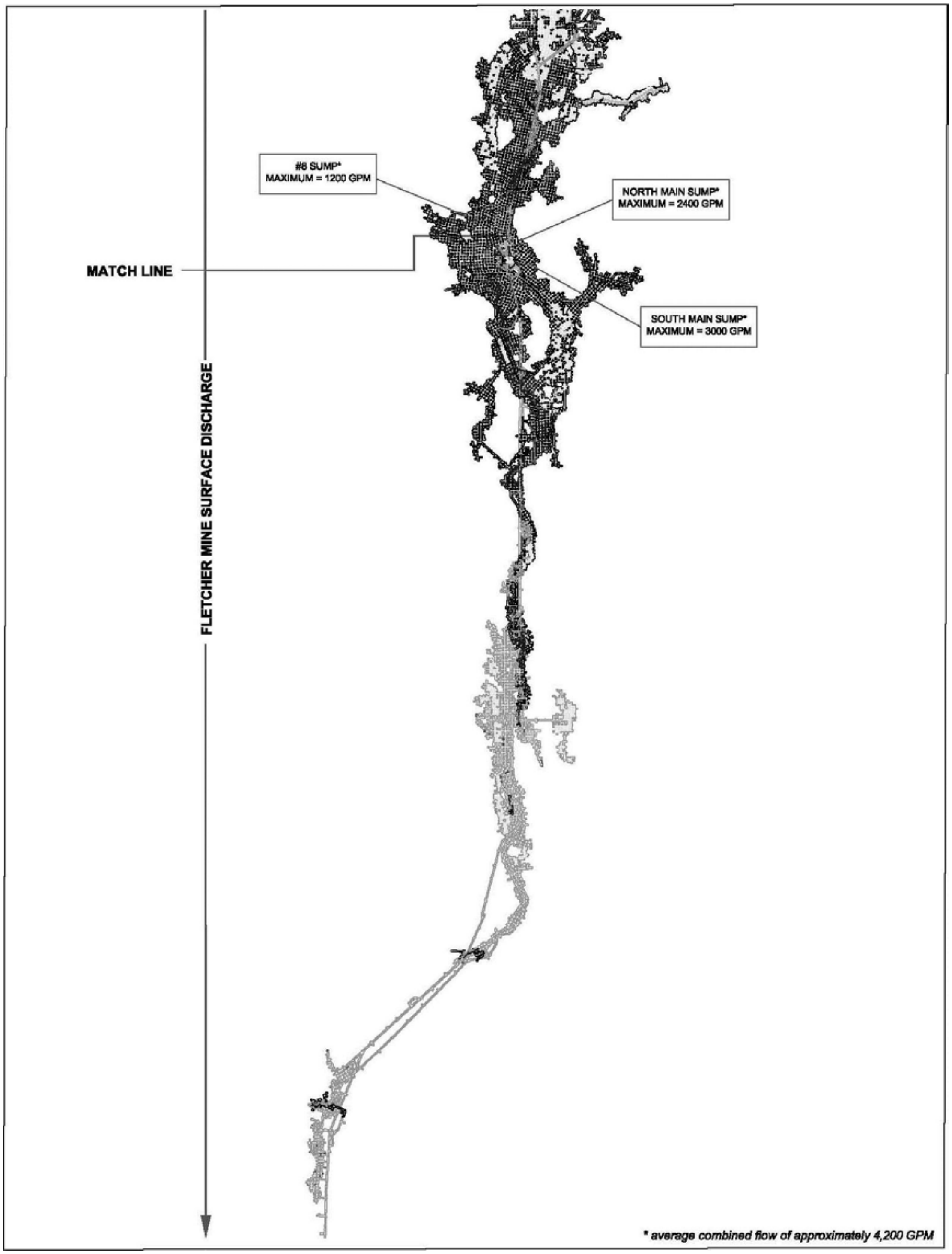


Figure 1-3. Layout of the Fletcher/West Fork Mine - South.

2. SUMMARY OF MINE WATER DATA

The Master UGWMP outlined the hierarchy of water management priorities listed below from highest priority to lowest.

1. Source Control
2. Water Minimization
3. Reuse or Reclamation
4. Water Treatment
5. Discharge

Because source control has been identified as the first water management priority, source identification is a fundamental part of the planning effort for potential measures to control metals loading. Load is a function of both flow and concentration. Therefore, these components were each examined independently at the Fletcher/West Fork Mine, as described below. The flow and water quality data are organized and evaluated based on where flow is discharged to the surface (i.e. Fletcher or West Fork).

2.1 WATER SOURCES AND MOVEMENT

An inventory of water in the Fletcher/West Fork Mine was compiled for this plan based on the best available information and includes the following components:

- Total mine water flows
- Sources of mine water
- Current underground management of mine water

Each of these components is described below.

2.1.1 Total Mine Water Flows

Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Fletcher/West Fork Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-1.

Table 2-1. Mine Water Flowrates at Fletcher/West Fork Mine.

Quantity	Value
Average Flow Pumped to Surface from West Fork	1,400 gpm
Maximum Mine Water Pumping Capacity at West Fork	2,500 gpm
Average Flow Pumped to Surface from Fletcher	4,200 gpm
Maximum Mine Water Pumping Capacity at Fletcher	6,600 gpm

A flow meter was installed on the surface discharge line that conveys flow from the Fletcher sumps in November 2011. Readings collected since then indicate an average flowrate of approximately 4,200 gpm. Flow data are not currently directly measured at the West Fork mine water sump, but are estimated from pump capacities and historical measurements. The average flows reported in Table 2-1 represents Doe Run's best estimate based on available information. The maximum pumping capacity is based only on pump capacity and does not necessarily reflect maximum flows actually pumped from the mine. It is known that flow rate can vary over time depending on factors such as season or where the mine is being advanced, however the values in Table 2-1 represent the best available estimate.

2.1.2 Sources of Mine Water

Water enters the Fletcher/West Fork Mine mainly through general seepage, with some flows from shafts. Given the diffuse nature of most water entering the mine it is difficult, if not impossible, to accurately measure all sources. However, mine water flows were measured at some key locations in the Fletcher/West Fork Mine to support preparation of this plan. Based on these flow measurements and information provided by Doe Run personnel, the major flow distribution of mine water pumped to the surface at Fletcher/West Fork is as follows:

- Approximately eighty percent of the total mine water flow going to the Fletcher sumps (approximately 3,500 gpm on average) is from the south part of the mine.
- Approximately twenty percent of the total mine water flow going to the Fletcher sumps (approximately 700 gpm on average) is from the north part of the mine.
- Approximately two thirds of the total mine water going to the West Fork sump (approximately 900 gpm on average) is from the north part of the mine and the other one third is from the south part of the mine and general seepage.

The flow distribution is depicted schematically in Figures 2-1 and 2-2.

Flow measurements were collected by Doe Run and LimnoTech staff at several locations in Fletcher/West Fork Mine on January 25, February 17, and March 15, 2012 as shown in Figures 2-1 and 2-2. Measurements were collected using both a velocity meter with dimensional measurements of ditches (width and depth) and an ISCO 4230 level measuring instrument with a 12-inch section of pipe fitted with a flow metering insert. The measurements provide an indication of flow rates for those days. Total flows measured were somewhat lower than the total average flow estimates, but generally corroborate the average flow range, as some flow variability is expected. Flows into Fletcher/West Fork Mine, as with all mines, vary over time as a result of several factors including, but not necessarily limited to, recent precipitation, changing location of mining activities (which may encounter new fractures, boreholes, etc.), and in-mine pumping operations. With respect to the latter item, it is suspected that general maintenance activities resulted in a temporary reduction in flow coming from the north part of Fletcher Mine during the period when the 280 gpm rate was measured (1/25/12).

At the south end of the Fletcher/West Fork Mine, in an area referred to as RC West Fork (Reynolds/Corridon/West Fork:RCWF), a great deal of incoming flow occurs from fractures, exploratory boreholes and roof bolt holes. Although each individual source in this area is relatively small, there are dozens of incoming flows in this localized area that cumulatively provide a significant amount of water. The range of flows coming from these sources was estimated by timing the fill rate of a five-gallon bucket at a sampling of locations on January 25, 2012. Flow rates ranged from approximately 2 gpm from a fracture to approximately 50 gpm from a relief drill hole. Flow measurements were collected in the open channel downstream of the working face to provide an estimate of the total flow coming from the coreholes and fractures in this area. Measurements indicated a total flow of approximately 1,300 gpm.

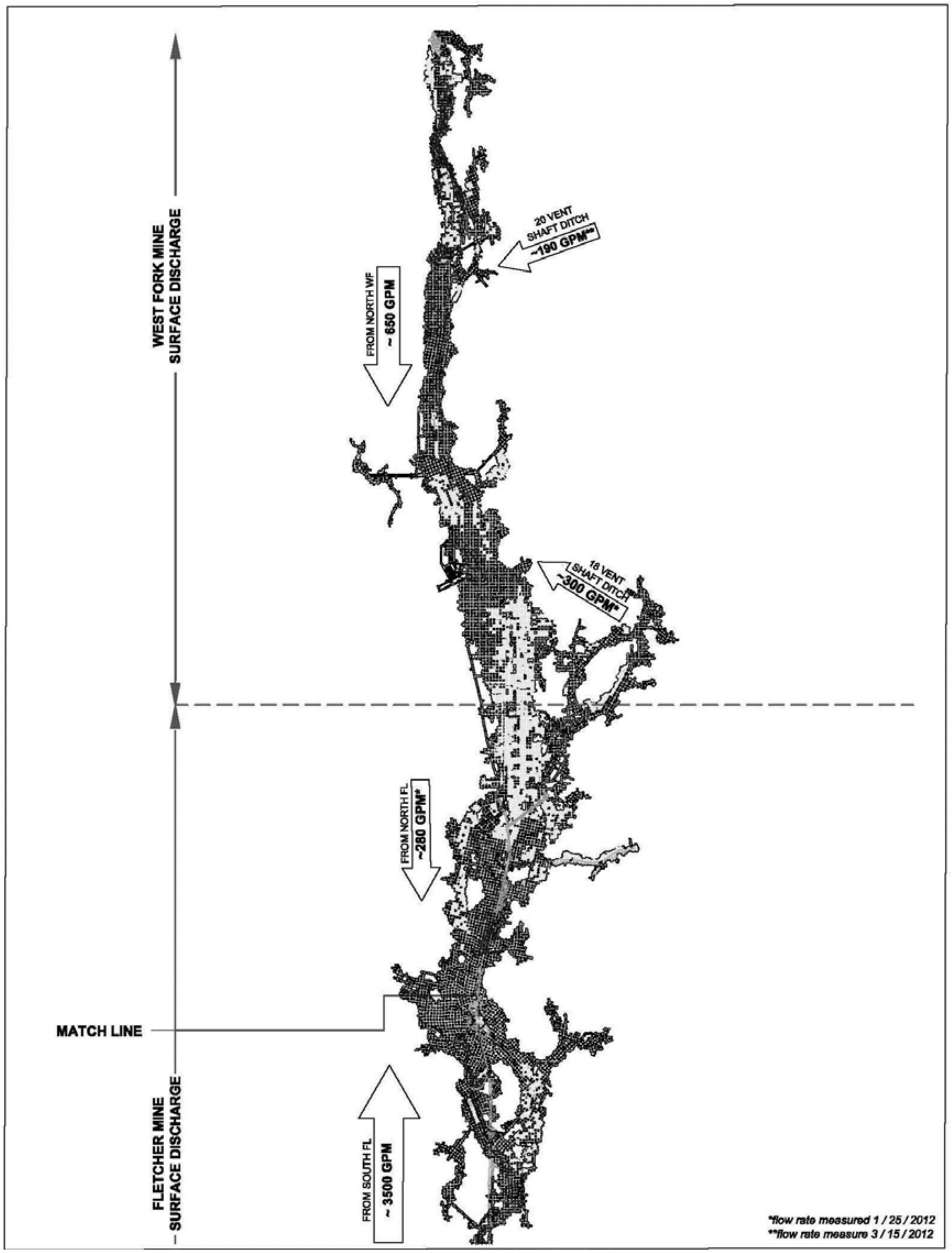


Figure 2-1. Mine Water Flow Summary for the Fletcher/West Fork Mine - North.

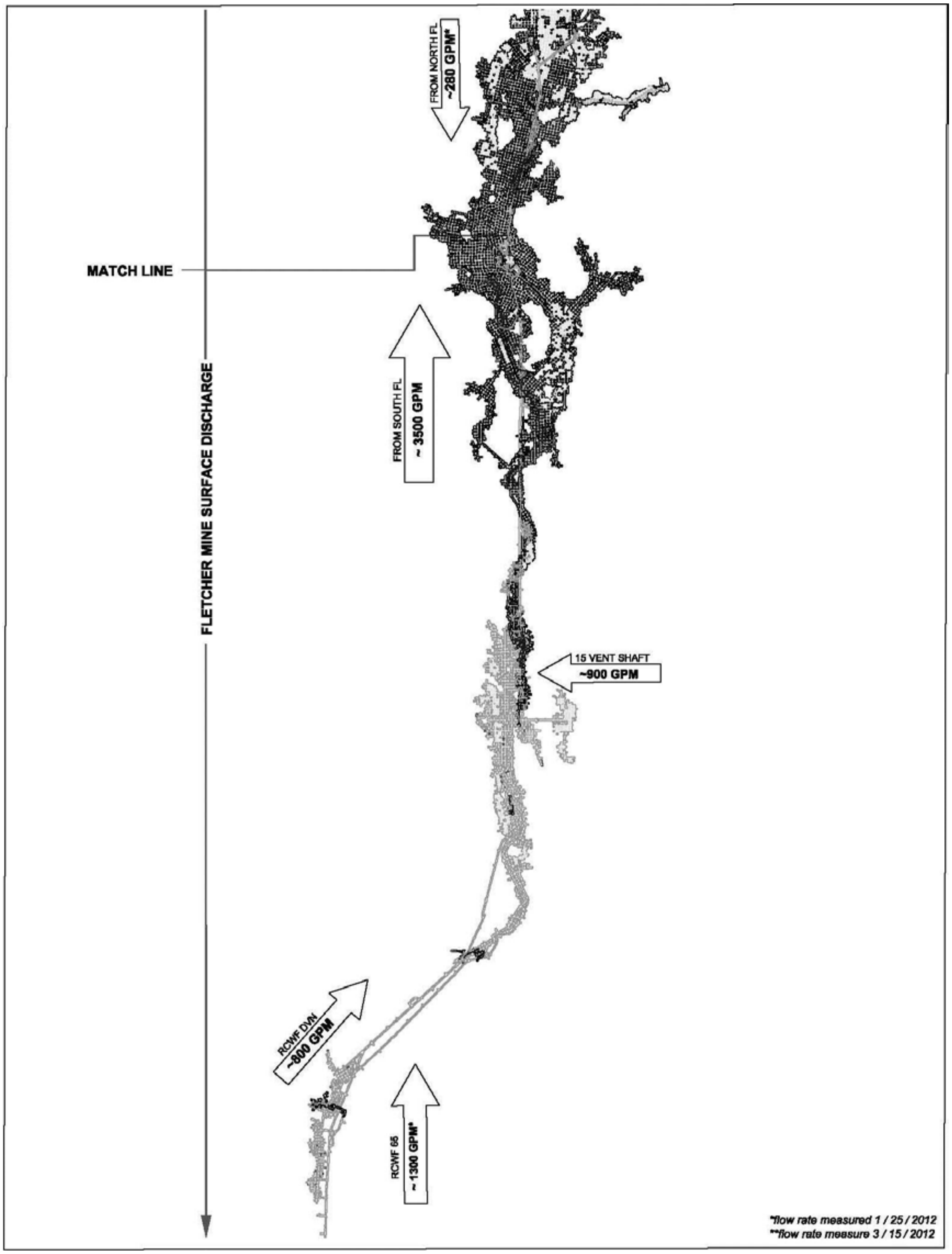


Figure 2-2. Mine Water Flow Summary for the Fletcher/West Fork Mine - South.

2.1.3 Current Underground Water Management Practices

Current practices to manage mine water at Fletcher/West Fork Mine are primarily focused on maintaining safe and workable conditions in the mine and are not specifically designed to maintain or improve water quality. These practices include the following:

- Piping – Piping of water through the mine has historically been performed to facilitate transfer pumping from one location to another, where mine grades prevent gravity flow. Piping is discussed in greater detail in Section 3.1.1.
- Sump cleaning – Sump cleaning, or mucking as it is called by mine personnel, has historically been performed, as needed, to maintain performance of the mine water sump pumps. Sump mucking is discussed in greater detail in Section 3.4.9.
- Corehole plugging – Plugging of coreholes that contribute significant flows, where feasible, has historically been performed at Fletcher/West Fork Mine. Corehole plugging is discussed further in Section 3.3.

Although it may not be their specific intent, these practices may have an incidental benefit of protecting water quality. These and other potential water management practices to preserve or improve water quality are discussed in greater detail in Section 3 of this Plan.

2.2 MINE WATER QUALITY

To support development of this and other water management plans at Doe Run mine/mill facilities, a water quality sampling program was implemented between December 2010 and June 2011. Three rounds of underground water sampling were performed at each mine. The details of the underground sampling program, including the sampling results, are presented in the Underground Water Sampling and Analysis Plan Report (LimnoTech, August 4, 2011). Sampling locations for these events are shown in Figures 2-3 and 2-4. A more detailed map of Fletcher/West Fork Mine showing sample locations, water flow paths, pump information, and sampling results for total and dissolved lead and zinc, is included as Appendix A.

These data were evaluated to better understand mine water quality at Fletcher/West Fork Mine and to discern factors that may improve or degrade mine water quality. Because the purpose of this UGWMP and the surface water management plan at Fletcher/West Fork is to be part of a comprehensive effort above and below ground to attain compliance with future final Missouri State Operating Permit (MSOP) future final limits for the discharge of mine water and other sources to waters of the State, the mine water data were evaluated in reference to the future final discharge limits in the MSOP for the Fletcher/West Fork Mine. The future final limits for the primary constituents of interest for outfall 001 for Fletcher Mine and outfall 001 for West Fork are summarized in Tables 2-2 and 2-3.

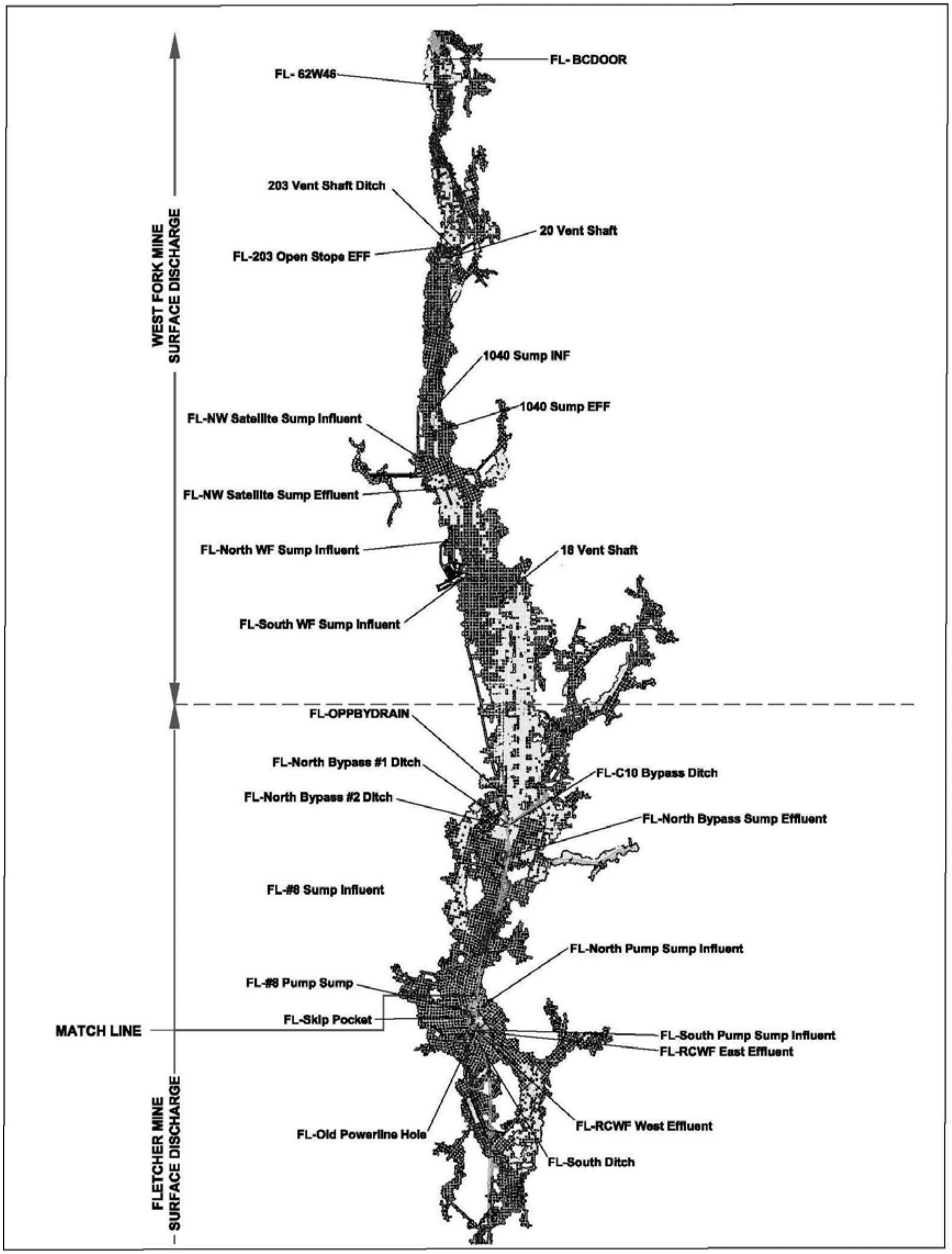


Figure 2-3. Mine Water Sampling Locations for the Fletcher/West Fork Mine - North.

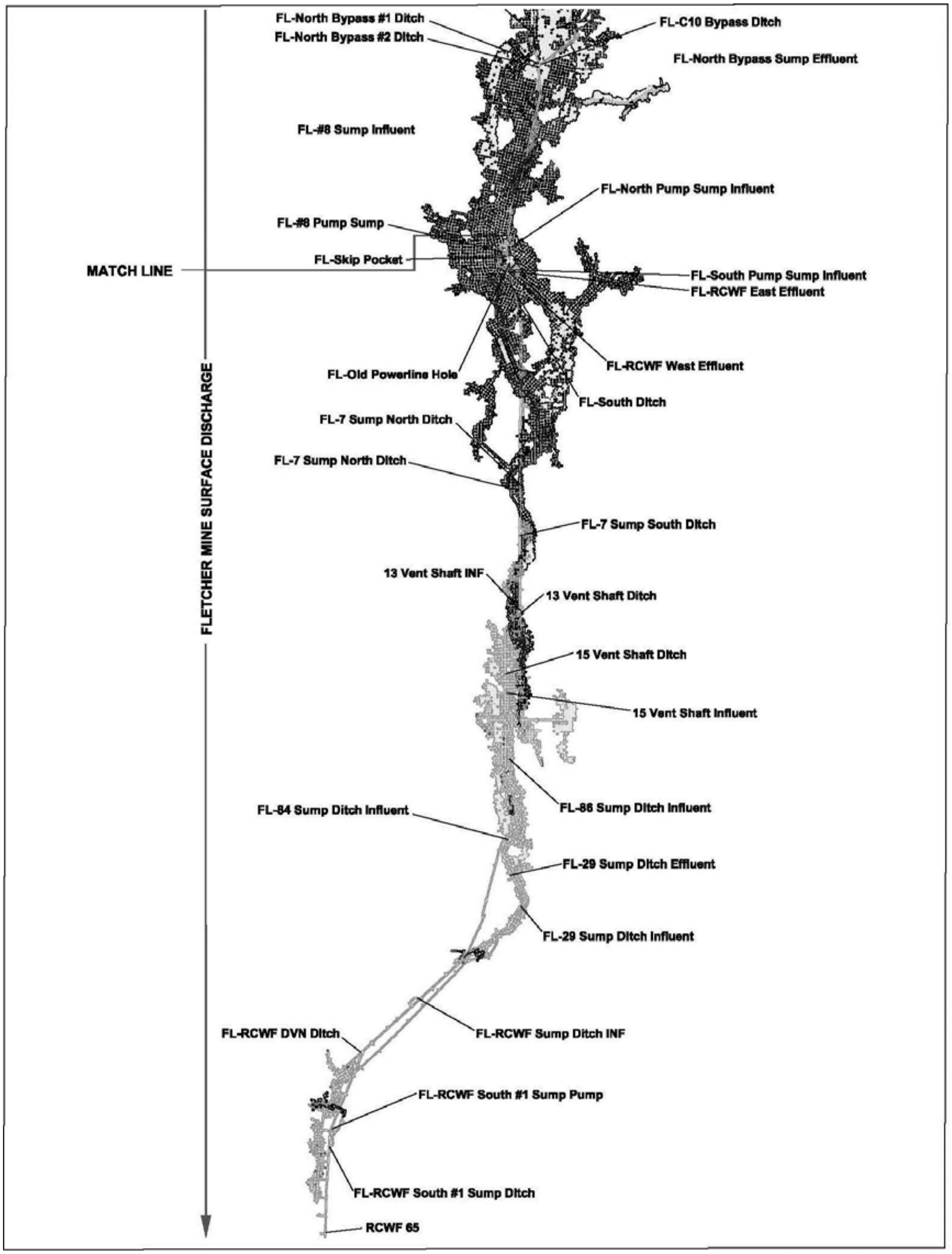


Figure 2-4. Mine Water Sampling Locations for the Fletcher/West Fork Mine - South.

Table 2-2. Future Final MSOP Limits for Fletcher Mine Outfall 001.

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.0	0.5
Copper, total recoverable	82.1	40.9
Lead, total recoverable	23.0	11.5
Zinc, total recoverable	275.5	137.3

Table 2-3. Future Final MSOP Limits for West Fork Mine Outfall 001.

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.2	0.6
Copper, total recoverable	57.5	28.7
Lead, total recoverable	24.6	12.2
Zinc, total recoverable	523.1	260.7

The findings of this evaluation are presented in the following sections.

2.2.1 Incoming Mine Water Quality

Incoming mine water quality at Fletcher Mine was originally intended to be characterized by samples collected at three locations: "Old Powerline Hole", "13 Vent Shaft INF" and "15 Vent Shaft Influent". Old Powerline Hole is located near the main mine water sumps, and the other locations are in the south part of the mine. Three valid samples were collected from Old Powerline Hole, one valid sample was collected from 13 Vent Shaft, and three valid samples were collected from 15 Vent Shaft INF during the 2011 underground sampling program.

Upon review of the sampling locations, however, it was determined that not all of these locations were truly representative of incoming mine water, as described below:

- The Old Powerline Hole location is actually a former road rock hole located on the surface just outside the mill building. The hole is covered with a steel plate and asphalt.
- 13 Vent Shaft and 15 Vent Shaft would be representative of incoming mine water if the water was collected for analysis in the shafts themselves, before it reaches the floor of the shafts. This is often not possible, however, and some of the samples were collected from water flowing under the shaft bulkhead, which has already been exposed to mine materials.

In order to address these issues, an additional sample was collected at RCWF 65 in February 2012 to supplement the previously collected data on incoming mine water. At this location, water leaking directly from the back was sampled. The data are represented in Table 2-4.

No incoming mine water sampling locations had previously been identified at West Fork, so two locations were sampled in February 2012 to characterize incoming mine water there: "18 Vent Shaft" and "20 Vent Shaft". 18 Vent Shaft is located southeast of the main sump and 20 Vent Shaft is located in the north part of the mine. The sample from 18 Vent Shaft was collected directly as it flowed from the shaft, before exposure to the workings. This sample is a valid representation of incoming mine water. The sample from 20 Vent Shaft could not be collected from the shaft and was instead collected from water running under the bulkhead wall. Therefore, it is not actually representative of incoming mine water. The data are represented in Table 2-5.

Comparing the Fletcher results to the discharge future final limits presented in Table 2-2 shows that concentrations of primary metals in incoming mine water are generally below the future final permitted discharge limits with the exception of the total lead results for the RCWF65 sample and duplicate which exceeded the future final monthly average discharge limit. The elevated lead concentration at RCWF65 could be a function of the rock strata through which the water flows before entering the mine. It is not certain that all water entering the mine will have the same quality as is reflected in this sample.

Comparing the West Fork results to the future final discharge limits presented in Tables 2-3 shows that concentrations of primary metals in incoming mine water were below the future final permitted discharge limits. It is not certain that all water entering the mine will have the same quality as is reflected in these samples.

Table 2-4. Incoming Mine Water Quality at Fletcher Mine.

Location	Sampling Date	Parameter				
		Total Cadmium (μg/L)	Total Copper (μg/L)	Total Lead (μg/L)	Total Zinc (μg/L)	TSS (mg/L)
FL-RCWF65	2/17/2012	ND (0.5)	ND (1)	14.6	6	ND (5)
FL-9-RCWF65*	2/17/2012	0.08	ND (1.07)	12	10	ND (5)
*Duplicate						

Table 2-5. Incoming Mine Water Quality at West Fork Mine.

Location	Sampling Date	Parameter				
		Total Cadmium (μg/L)	Total Copper (μg/L)	Total Lead (μg/L)	Total Zinc (μg/L)	TSS (mg/L)
FL-18 Vent Shaft	2/17/2012	ND (0.5)	ND (1)	ND (1)	ND (10)	ND (5)
FL-9-18 Vent Shaft*	2/17/2012	ND (0.11)	ND (1.07)	ND (1.12)	1.4	ND (5)
*Duplicate						

2.2.2 Comparison of Incoming and Outgoing Mine Water

Inspection of the water data collected throughout Fletcher/West Fork Mine shows that samples at many locations contain concentrations of target metals above the future final permitted effluent limits, so incoming and outgoing mine water (i.e., mine water pumped to the surface) were compared to discern which of those metals exceed their respective future final discharge limits.

These comparisons of samples taken of incoming mine water at Fletcher Mine with mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-5, 2-6, 2-7, and 2-8, respectively. As stated above, incoming mine water quality is characterized by samples collected at RCWF65.

Because there is no safe direct sampling access to the main sumps, outgoing mine water is characterized by the samples collected at #8 Pump Sump, South Pump Sump Influent, and North Pump Sump Influent. Ideally, samples characterizing the outgoing mine water would be collected from a location as close as possible to the mine water sump pumps but, due to the configuration of the main sumps at Fletcher Mine, such a location cannot be safely or easily accessed. Because the main mine water sumps at Fletcher Mine are sampled in the influent ditch, they do not reflect any settling that may occur in the mine water sumps before mine water is pumped to the surface. Samples were collected at the North Pump Sump Influent, #8 Pump Sump, and South Pump Sump Influent locations one, two, and three times during the 2011 sampling program, respectively. The following observations can be made from the data shown in Figures 2-5, 2-6, 2-7, and 2-8:

- Cadmium: The incoming mine water sample was below the future final effluent limits for cadmium. Future final limits were exceeded in the mine sump ditch samples with the exception of the #8 Pump Sump sample collected on 2/8/11.
- Copper: The incoming mine water sample was below the future final effluent limits for copper. Two mine sump ditch samples exceeded the future final monthly average copper effluent limit.
- Lead: The incoming mine water sample exceeded the future final monthly average discharge limit for lead. All mine sump ditch samples exceeded the monthly average and daily maximum future final limits for lead with the exception of the #8 Pump Sump sample collected on 2/8/11.
- Zinc: The incoming mine water sample was below the future final effluent limits for zinc. All mine sump ditch samples exceeded the daily maximum and monthly average zinc future final effluent limits with the exception of the North Pump Sump Influent sample on 6/8/11, which only exceeded the future final daily maximum limit, and the #8 Pump Sump sample on 2/8/11, which was below the future final limits for zinc.

The comparisons of samples taken of incoming mine water at West Fork Mine with mine water that is pumped to the surface are depicted graphically for total cadmium, total copper, total lead, and total zinc in Figures 2-9, 2-10, 2-11, and 2-12, respectively. As stated above, incoming mine water quality is characterized by sample collected at 18 Vent Shaft.

Because there is no safe direct sampling access to the main sumps, outgoing mine water is characterized by the samples collected at North WF Sump Influent and South WF Sump Influent. Ideally, samples characterizing the outgoing mine water would be collected from a location as close as possible to the mine water sump pumps but, due to the configuration of the main sumps at West Fork, such a location cannot be safely or easily accessed. Because the main mine water sumps at West Fork Mine are sampled in the influent ditch, they do not reflect any settling that may occur in the mine water sumps before mine water is pumped to the surface. Samples were collected at the North and South WF Sump Influent locations three times during the 2011 sampling program. The following observations can be made from the data shown in Figures 2-9, 2-10, 2-11, and 2-21:

- Cadmium: The incoming mine water sample was below the future final effluent limits for cadmium. All future final limits were exceeded in the mine sump ditch samples.
- Copper: The incoming mine water sample was well below the future final effluent limits for copper. The mine sump ditch samples were also below the final limits.
- Lead: The incoming mine water sample was well below the future final effluent limits for lead. All outfall 001 final limits were exceeded in the mine sump ditch samples.
- Zinc: The incoming mine water sample was below the future final effluent limits for zinc. All outfall 001 future final limits were exceeded in the mine sump ditch samples.

These results suggest that exposure of mine water to the mine workings at Fletcher/West Fork Mine can result in significant degradation of water quality, in part likely due to the increase in total suspended solids. The relationship between increased metals concentrations and increased suspended solids in mine water is discussed in Section 2.2.4 of this plan.

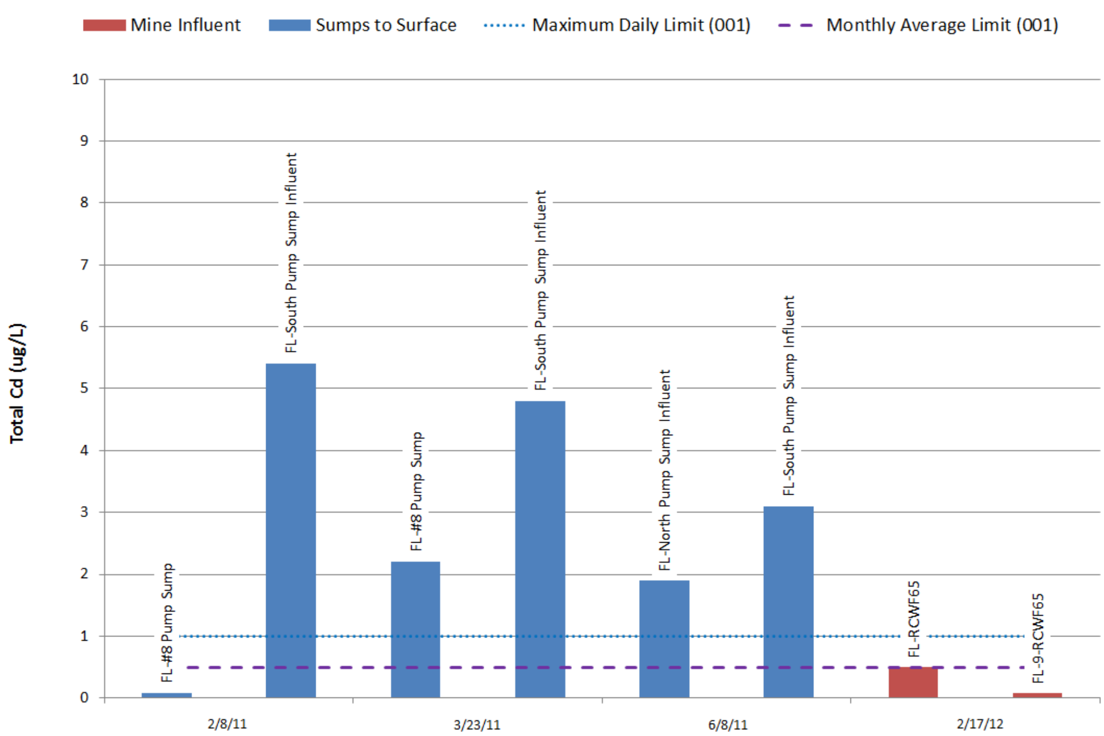


Figure 2-5. Incoming vs. Outgoing Mine Water Quality at Fletcher Mine: Total Cadmium.

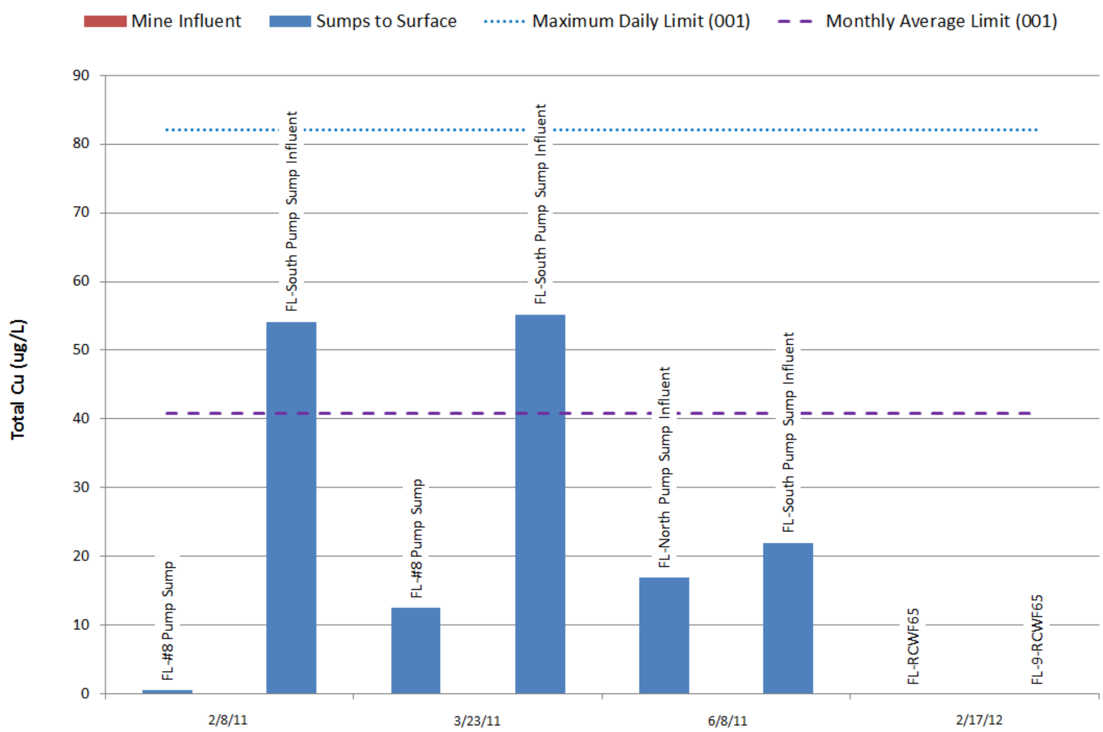


Figure 2-6. Incoming vs. Outgoing Mine Water Quality at Fletcher Mine: Total Copper.

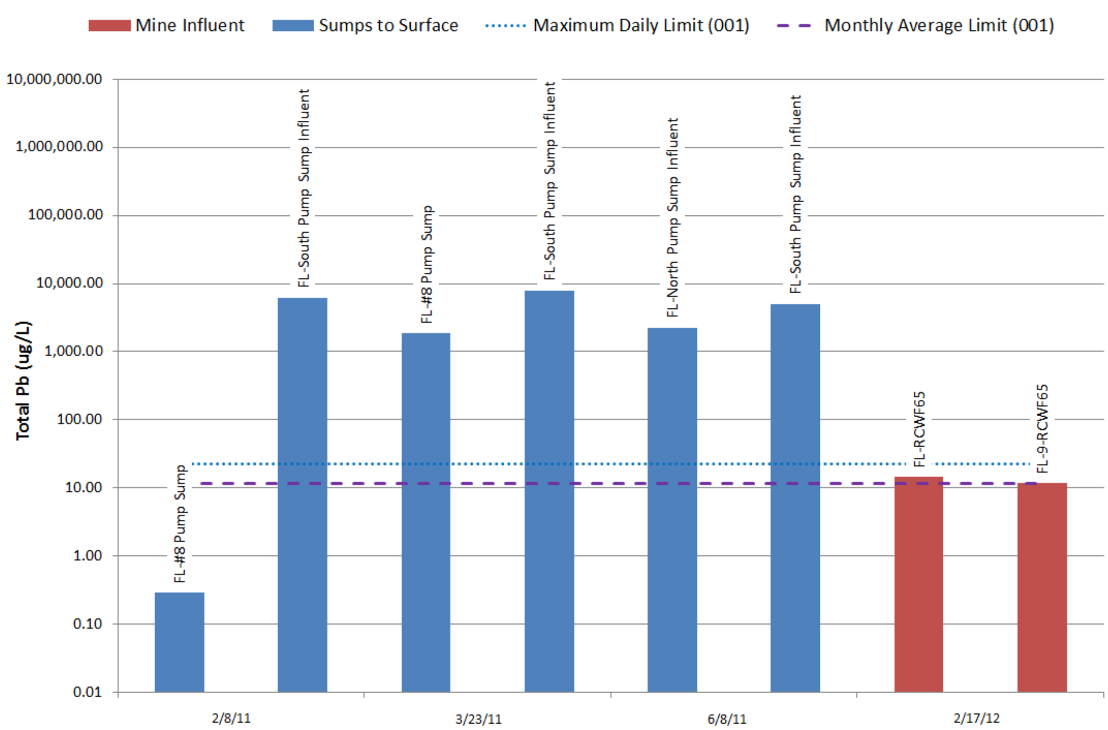


Figure 2-7. Incoming vs. Outgoing Mine Water Quality at Fletcher Mine: Total Lead (Note: log scale).

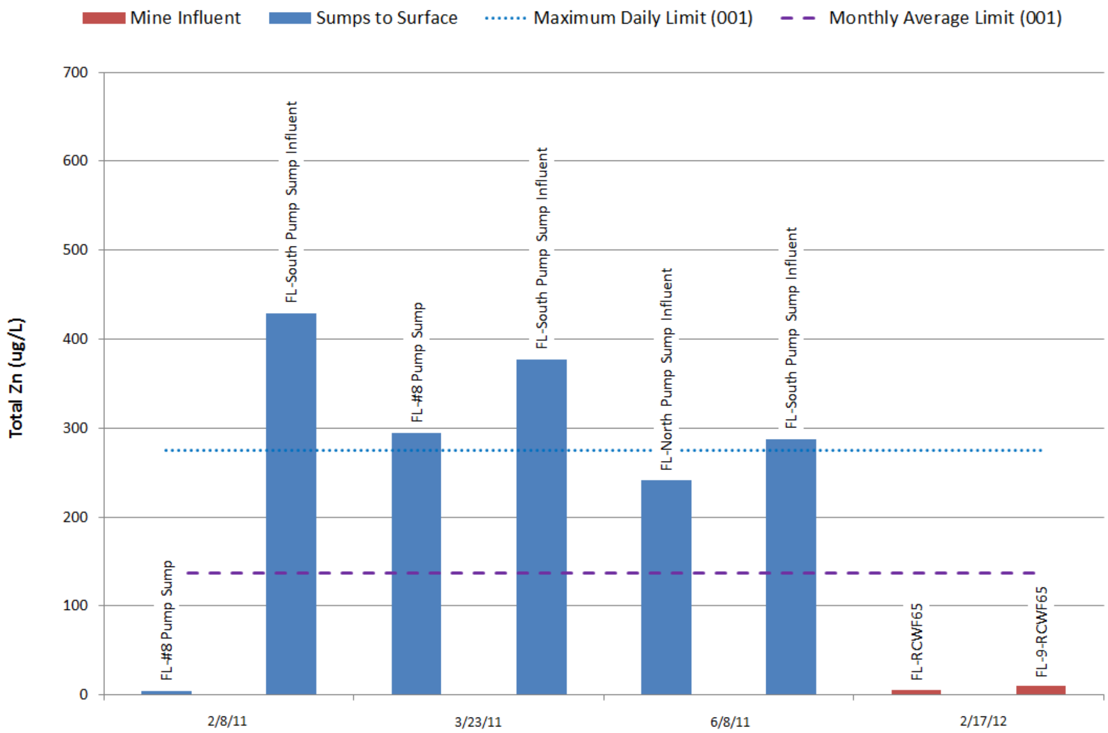


Figure 2-8. Incoming vs. Outgoing Mine Water Quality at Fletcher Mine: Total Zinc.

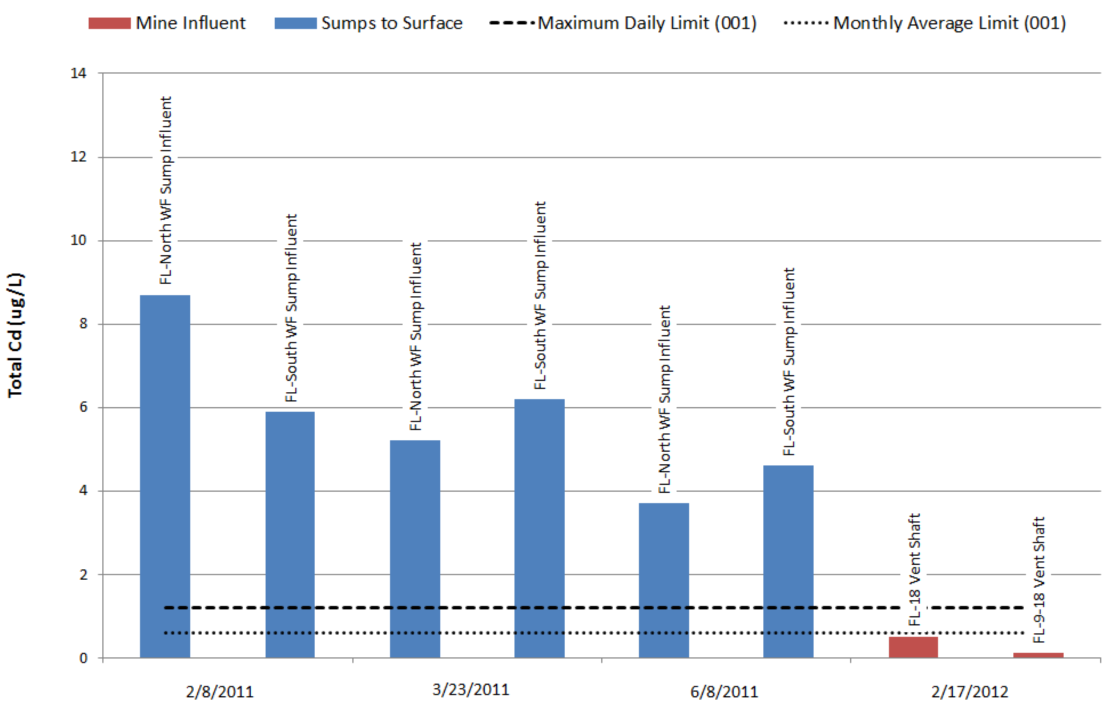


Figure 2-9. Incoming vs. Outgoing Mine Water Quality at West Fork Mine: Total Cadmium.

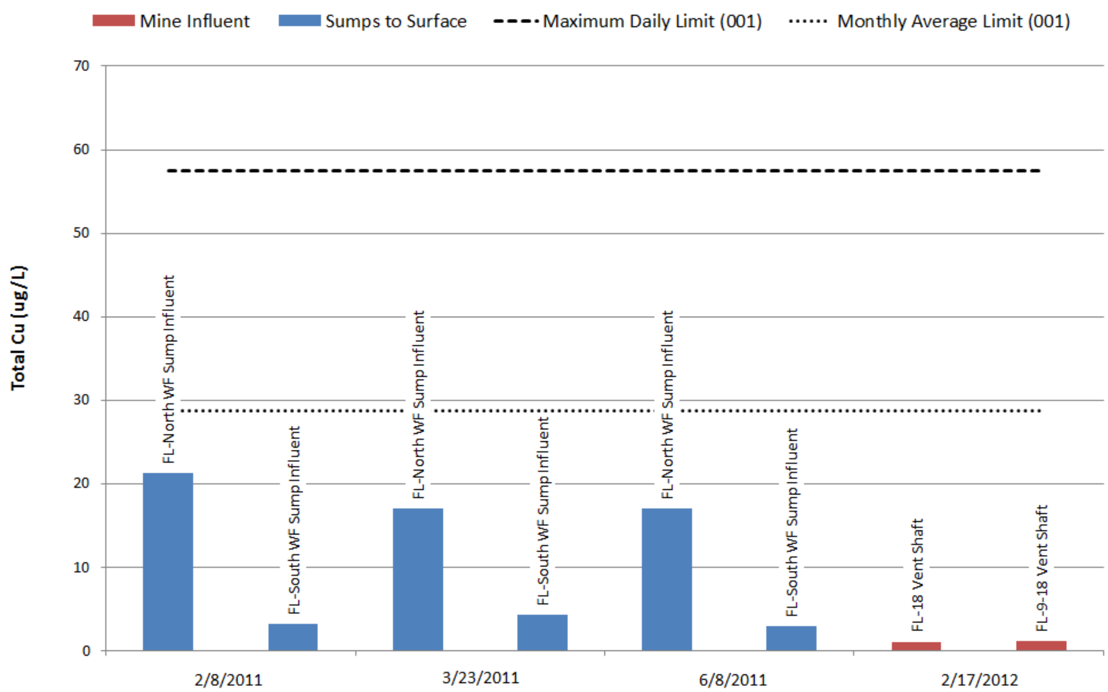


Figure 2-10. Incoming vs. Outgoing Mine Water Quality at West Fork Mine: Total Copper.

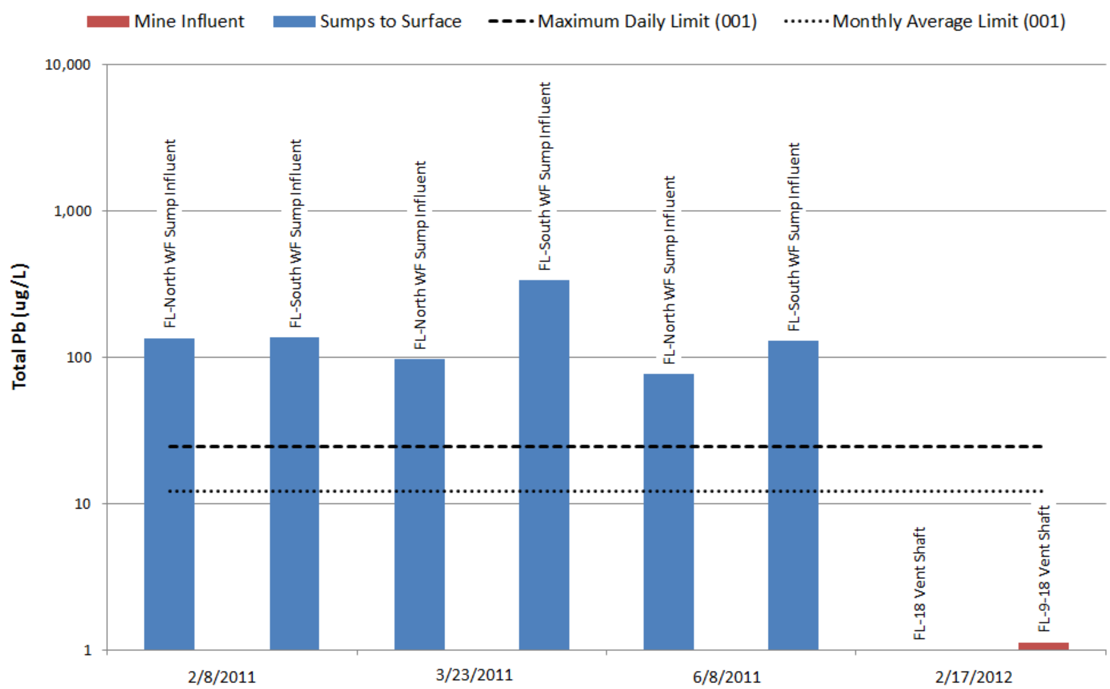


Figure 2-11. Incoming vs. Outgoing Mine Water Quality at West Fork Mine: Total Lead (Note: log scale).

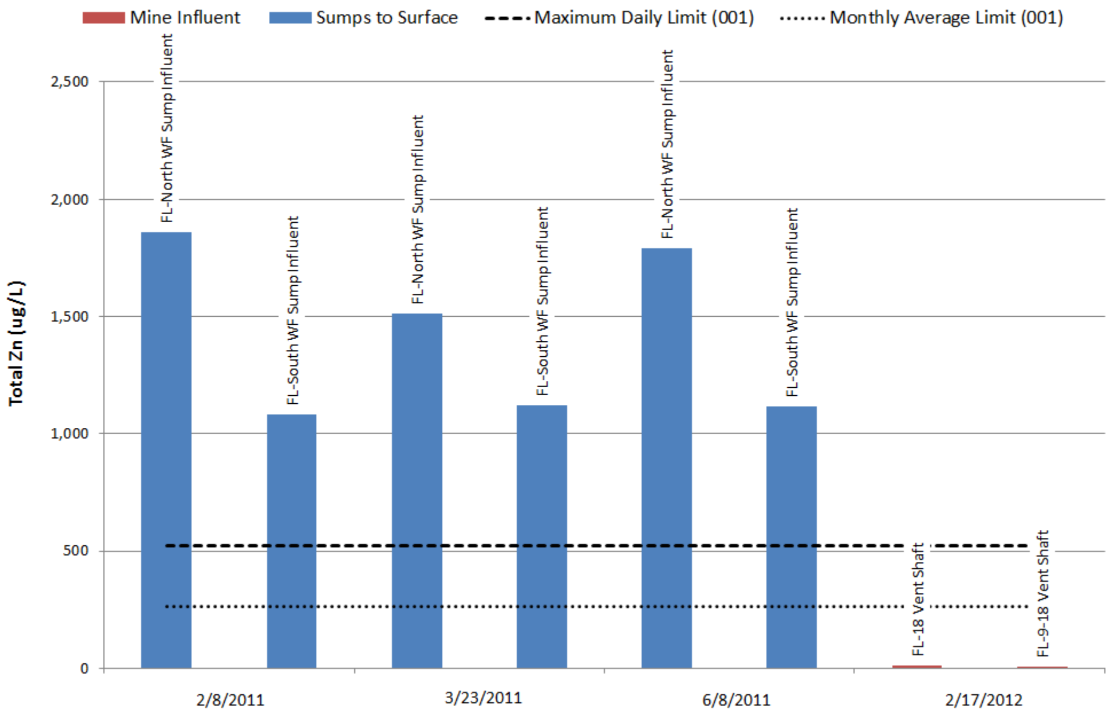


Figure 2-12. Incoming vs. Outgoing Mine Water Quality at West Fork Mine: Total Zinc.

2.2.3 Spatial Variation in Mine Water Quality

A majority of the mine water that is currently pumped to the surface at Fletcher Mine comes from the south end of the mine. However, although the south mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the three parts. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the north and south were compared. The north mine sampling locations include #8 Pump Sump, # Sump Influent, C10 Bypass Ditch, North Bypass #1 Ditch, North Bypass #2 Ditch, North Bypass Sump Effluent, North Pump Sump Influent, and Opp By Drain. The south mine sampling locations include RCWF South #1 Sump Ditch, RCWF South #1 Sump Pump, RCWF DVN Ditch, RCWF Sump Ditch INF, 86 Sump Ditch Influent, 84 Sump Ditch Influent, 7 Sump South Ditch, 7 Sump North Ditch, 29 Sump Ditch Influent, 29 Sump Ditch Effluent, 15 Vent Shaft Ditch, 13 Vent Shaft Ditch, RCWF East Effluent, RCWF West Effluent, South Pump Sump Influent, and Skip Pocket. Figures 2-13 through 2-16 show the comparison box plots of mine water quality between the north and south parts of Fletcher Mine. The box plots can be interpreted as follows:

- The dash in the center of each box represents the median value of the data set.
- The lower and upper edges of the box are the first and third quartiles (the first quartile represents the value that is equal to or greater than 25% of the data

and the third quartile represents the value that is equal to or greater than 75% of the data), respectively.

- The lower and upper whiskers are the 5th and 95th percentile values.

For ease of comparison, each plot also shows the future final effluent limits for that metal in the MSOP. The following observations can be made from these plots:

- Cadmium: The range of cadmium concentrations are generally similar in both parts of the mine, with equivalent 95th percentile concentrations of 19 μg/L and 5th percentile concentrations of 0.3 and 0.1 μg/L being measured in the north and south parts, respectively. The median cadmium concentration in the north mine (4 μg/L) is over six times higher than that observed in the south mine (0.6 μg/L). Most mine water samples in the north part of the mine exceeded both the monthly average and daily maximum cadmium future final effluent limits.

- Copper: Copper concentrations are also similar in both parts of the mine, with 95th percentile concentrations of 171 μg/L and 175 μg/L and 5th percentile concentrations of 1.0 and 0.5 μg/L being measured in the north and south parts, respectively. The median concentration in the south (13 μg/L) is higher than the median for the north (9 μg/L). These differences are slight and copper concentrations throughout the mine are generally comparable. Most mine water samples in Fletcher Mine are below the future final effluent limits for copper.

- Lead: The majority of mine water samples from both parts of the mine exceeded both the monthly average and maximum daily future final effluent limits for total lead. The range of lead concentrations is generally similar between the north and south parts of the mine, with 95th percentile concentrations of 18,628 μg/L and 25,224 μg/L and 5th percentile concentrations of 71 and 32 μg/L being measured in the north and south parts, respectively.

- Zinc: Zinc concentrations were higher in the north part of the mine than in the south, with the median concentration in the north (368 μg /L) being over three times that in the south (109 μg /L). Most mine water samples in the north part of the mine exceeded both the monthly average and daily maximum zinc future final effluent limits.

A majority of the mine water that is currently pumped to the surface at West Fork Mine comes from the north end of the mine. Although the north mine contributes a greater volume of water, it is necessary to examine the sampling data to determine how the relative loads of metals compare between the three parts. For this reason, total metals concentrations in mine water data (excluding incoming mine water data) for the north and south were compared. The north mine sampling locations include BCDOOR, 62W46, 203 Vent Shaft Ditch, 1040 Sump INF, 1040 Sump EFF, 203 Open Stope EFF, and North WF Sump Influent. The south mine sampling location is South WF Sump Influent. The relatively small number of samples collected from the south part of the mine (n=3) provides a constraint on the utility for comparing concentrations between the north and south. General observations are provided below and Figures 2-17 through 2-20 show the comparison box plots of mine water quality between the north and south parts of West Fork Mine.

For ease of comparison, each plot shows the future final effluent limits for that metal in the MSOP. The following general observations can be made from these plots:

- Cadmium: Cadmium appears to occur at a higher concentration in the south part of West Fork Mine, with the median concentration (6 μg/L) being twice that observed in the north part of the mine (3 μg/L). Most mine water samples exceeded the future final monthly average effluent limits for cadmium.
- Copper: Copper concentrations in the north part of the mine are higher than in the south, with the median (10 μg/L) being over three times that observed in the south (3 μg/L). The majority of copper concentrations were below the future final effluent limits for copper.
- Lead: Lead occurred at higher concentrations in the south mine than in the north mine, with the south median concentration (138 μg/L) being significantly higher than the north mine median (82 μg/L). The majority of mine water samples exceeded both the future final effluent limits for lead.
- Zinc: Zinc concentrations in the north part of the mine (1,740 μg/L) are somewhat higher than in the south (1,117 μg/L). Most samples exceeded the future final effluent limits for zinc.

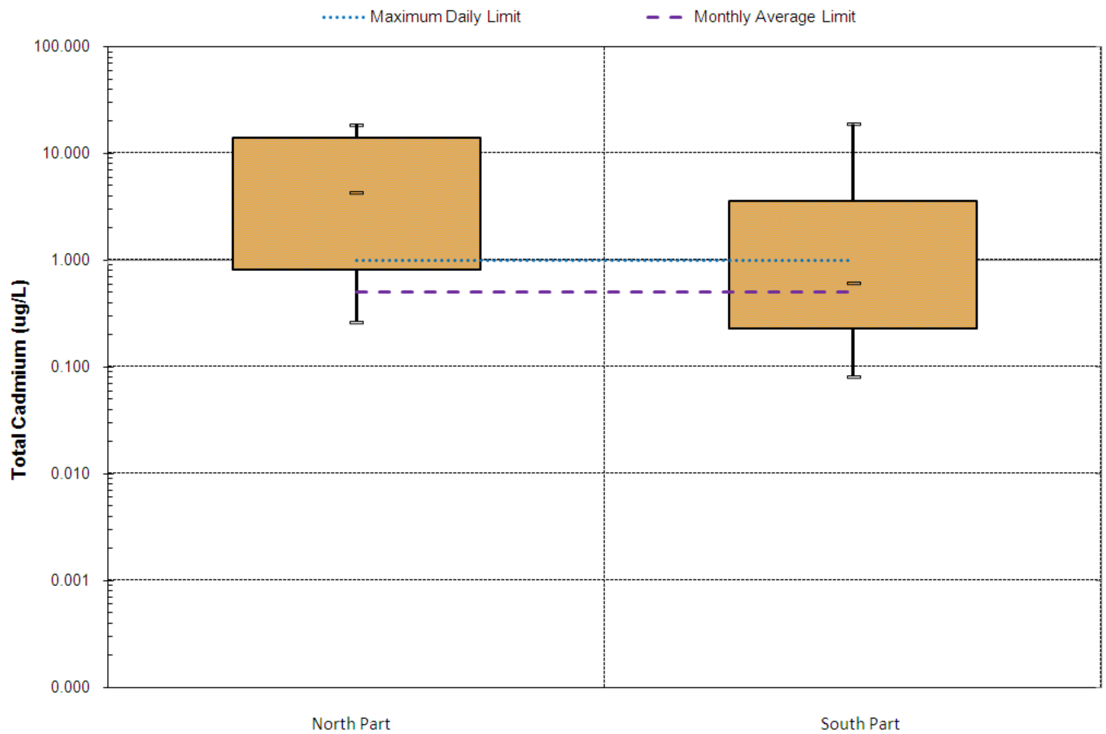


Figure 2-13. Comparison of Total Cadmium between the North and South Parts of Fletcher Mine.

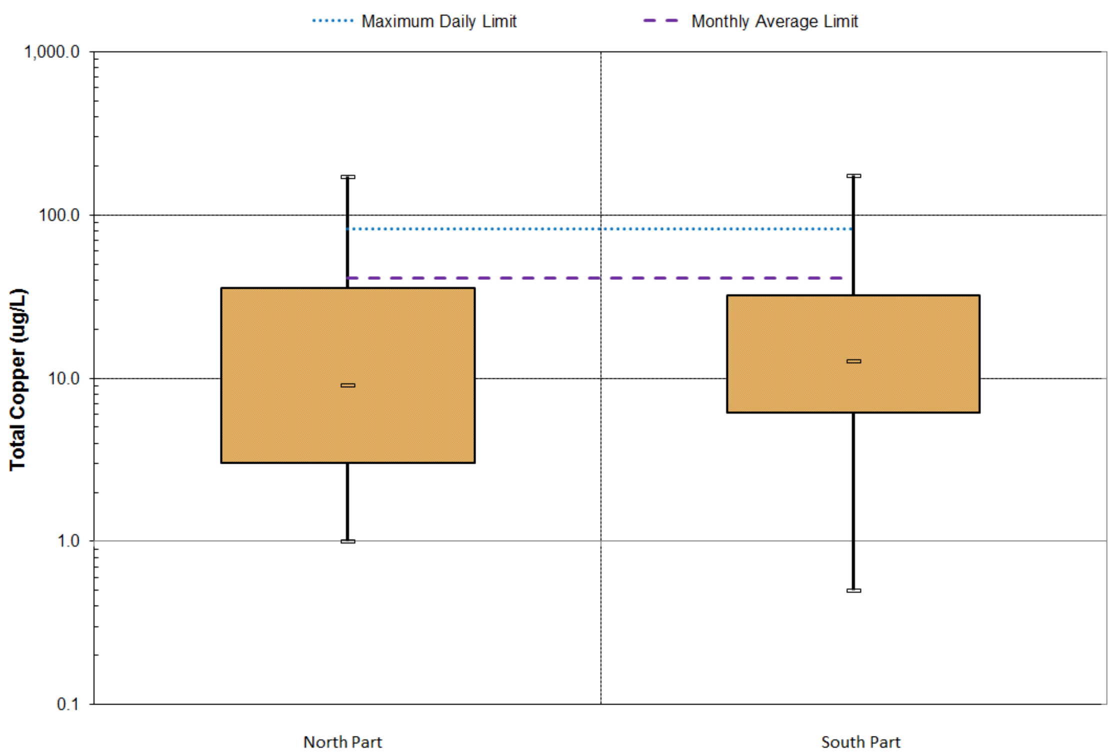


Figure 2-14. Comparison of Total Copper between the North and South Parts of Fletcher Mine.

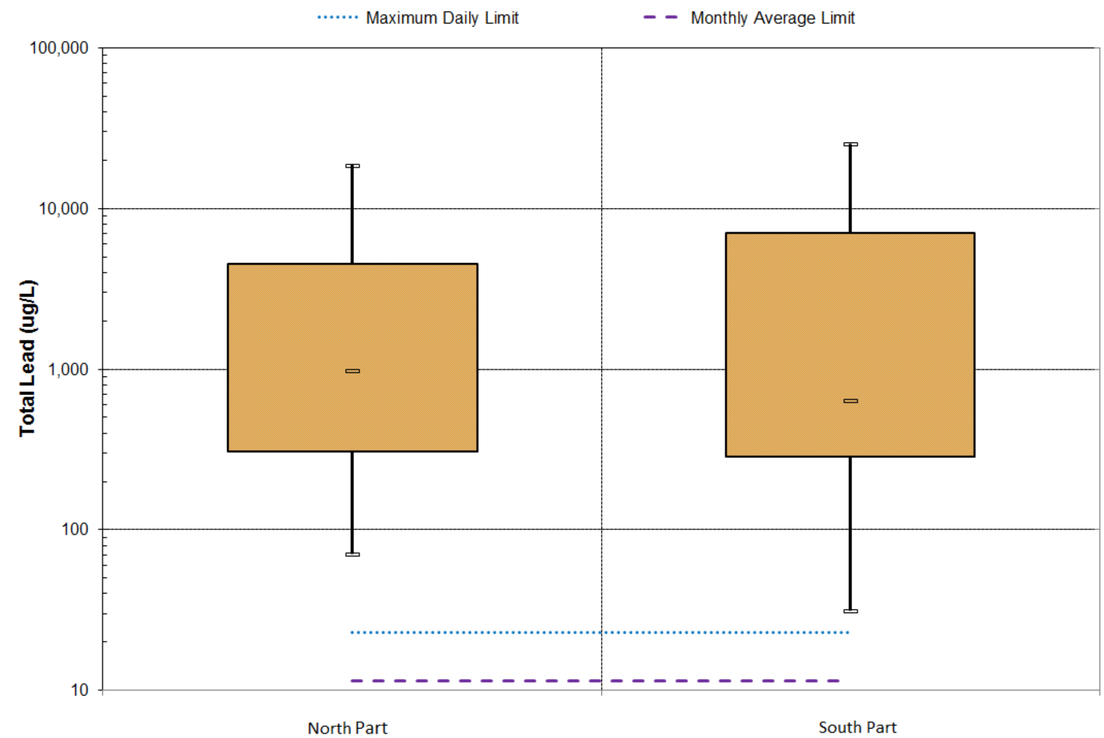


Figure 2-15. Comparison of Total Lead between the North and South Parts of Fletcher Mine.

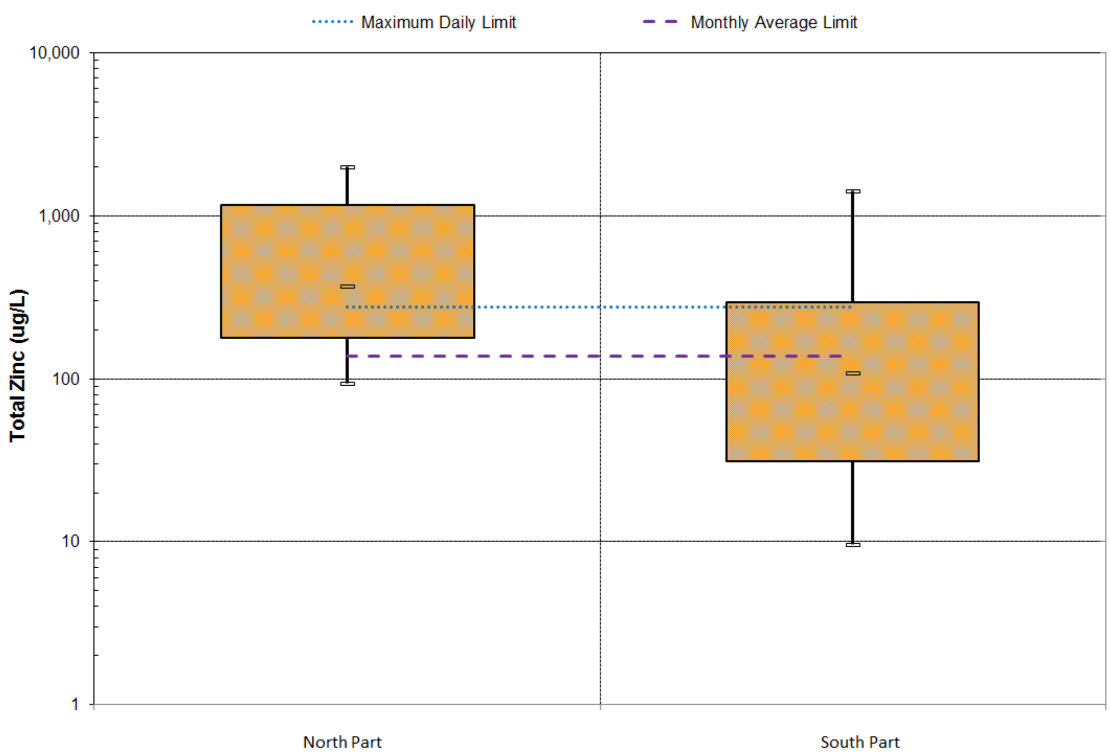


Figure 2-16. Comparison of Total Zinc between the North and South Parts of Fletcher Mine.

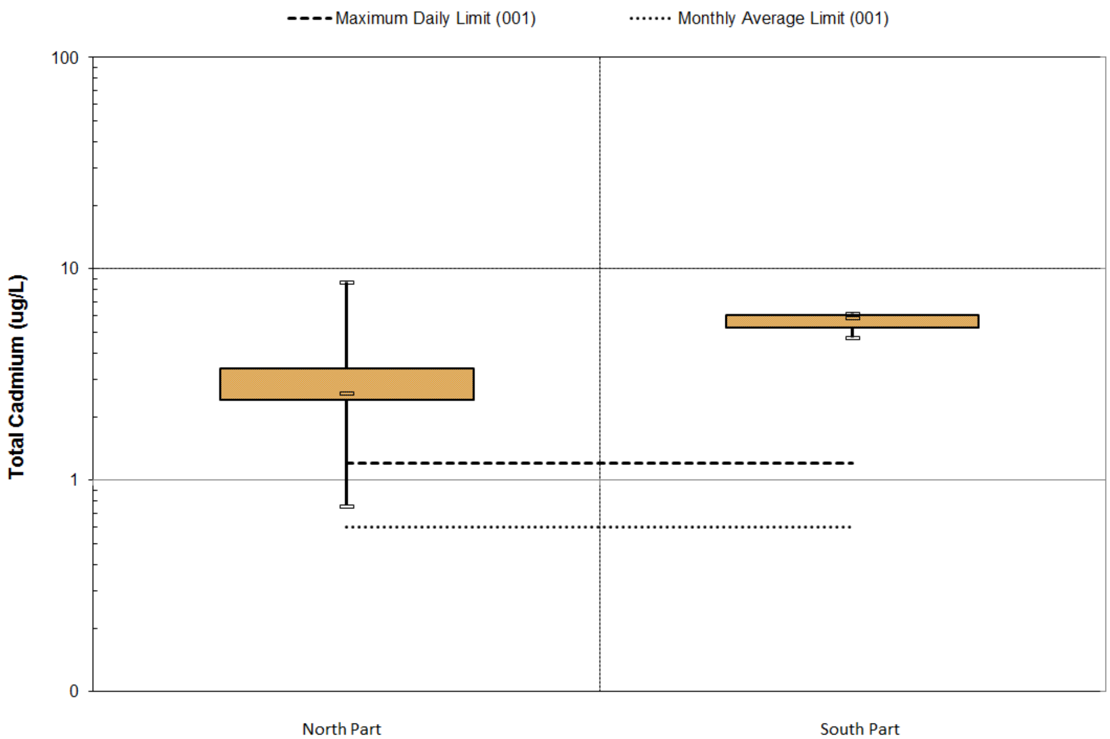


Figure 2-17. Comparison of Total Cadmium between the North and South Parts of West Fork Mine.

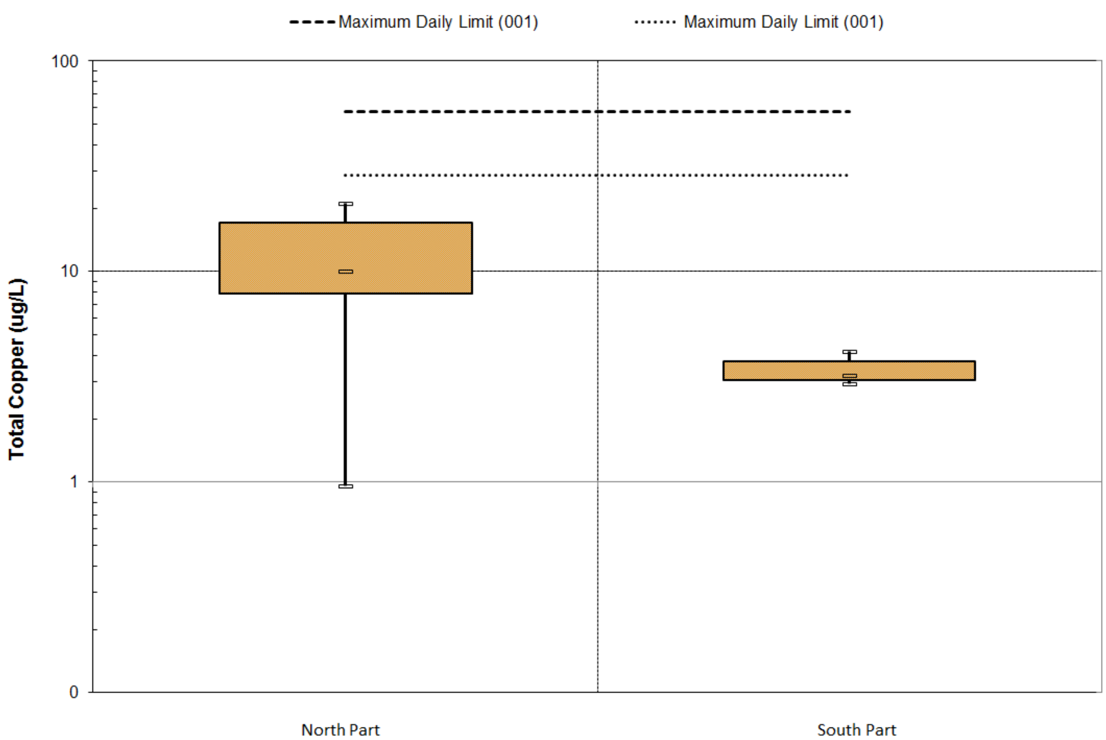


Figure 2-18. Comparison of Total Copper between the North and South Parts of West Fork Mine.

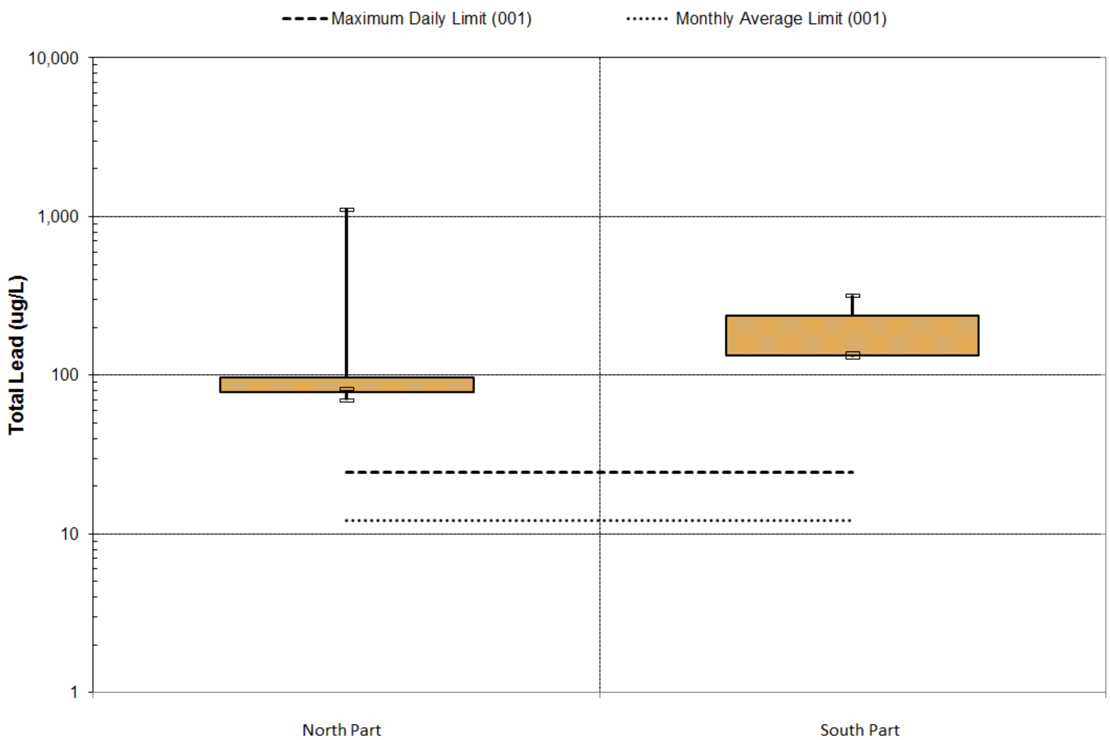


Figure 2-19. Comparison of Total Lead between the North and South Parts of West Fork Mine.

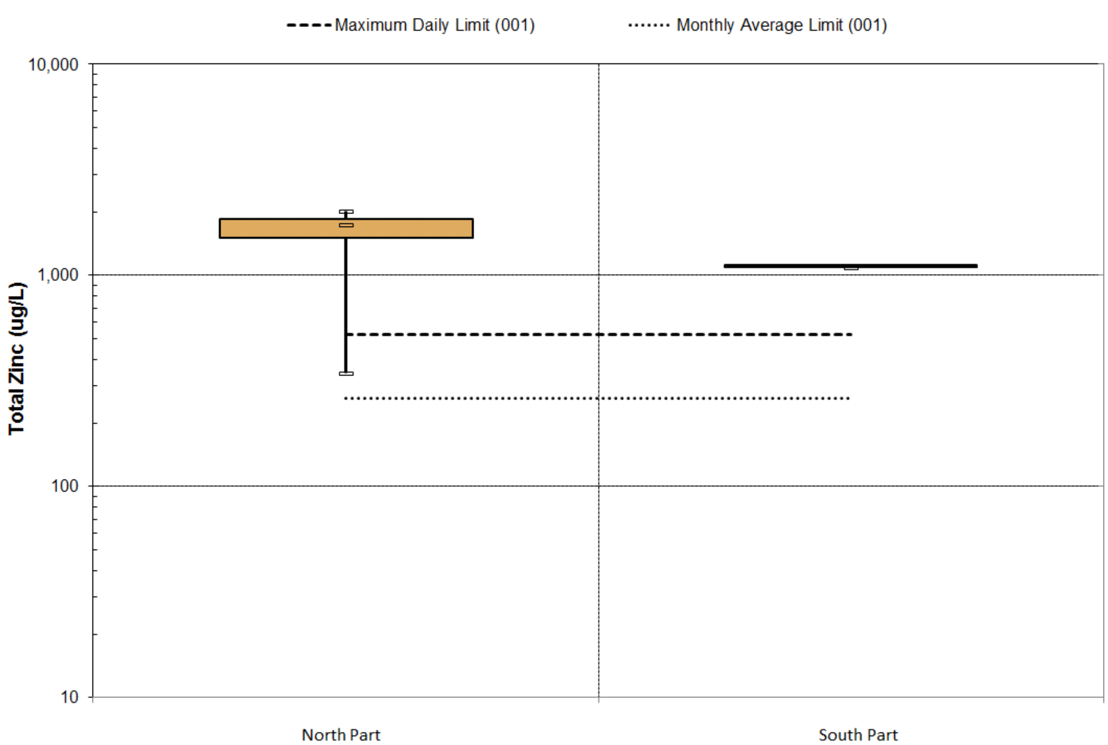


Figure 2-20. Comparison of Total Zinc between the North and South Parts of West Fork Mine.

2.2.4 Relationship Between Solids and Metals in Mine Water

Data from the Fletcher/West Fork Mine show that, in general, incoming mine water has relatively low metals concentrations compared to mine water that is pumped to the surface and that the concentrations of metals are significantly increased by exposure to the mine workings (Section 2.2.2). Therefore, the Fletcher/West Fork Mine data were evaluated to assess the relationship between metals and suspended solids. Figures 2-21 through 2-24 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS) in mine water from the Fletcher Mine. Figures 2-25 through 2-28 show correlation plots of total metals (cadmium, copper, lead, and zinc, respectively) with total suspended solids (TSS) in mine water from the West Fork Mine.

These results show varying relationships of metals with TSS at Fletcher/West Fork mine. The correlations are summarized in Tables 2-6 and 2-7. Data from the Fletcher Mine show moderate correlation between TSS and total cadmium (r^2 = 0.63), total copper (r^2 = 0.73) and total zinc (r^2 = 0.51). The correlation between TSS and total lead is relatively strong in the Fletcher mine water (r^2 = 0.92).

Regression of TSS and total metals in the West Fork mine water data show strong correlations for all four metals ($r^2 > 0.87$), but visual inspection of the data reveal apparent outliers (single data points with very high TSS concentration compared to other data in the set) in each data plot. Based on this observation, the apparent outliers were removed and the correlations were recalculated. Table 2-7 lists the r-squared values from both the original and edited regressions. Comparing these r-squared values, it is clear that the apparent outliers were driving the original high r-squared values. After removal of the apparent outlier, for example, the r-squared value for the TSS/total lead correlation dropped from 0.99 to 0.041.

Based on the relatively strong correlations observed between TSS and total metals, especially lead, at other Doe Run mines, it is unlikely that the low r-squared values observed in the edited regressions for West Fork accurately reflect the relationship between solids and metals there. On the other hand, it is difficult to rely on high correlations driven by single data points. At this time, therefore, no conclusions can be made from the regression of TSS and total metals in the West Fork mine water. Although the data do not show a strong correlation of TSS with total metals, there are far fewer data from West Fork than from Fletcher (24 data pairs for West Fork compared to 67 data pairs from Fletcher). More importantly, the West Fork mine water data has a high percentage of samples with TSS concentrations below the method detection limit (MDL), which are plotted using the MDL itself (5 mg/L).

Table 2-6. Correlations[1] of Total Metals with Total Suspended Solids at Fletcher Mine.

Parameter	Correlation with TSS (r^2 value)
Cadmium, Total	0.63
Copper, Total	0.73
Lead, Total	0.92
Zinc, Total	0.51

Table 2-7. Correlations of Total Metals with Total Suspended Solids at West Fork Mine.

Parameter	Correlation with TSS (r^2 value including apparent outlier)	Correlation with TSS (r^2 value excluding apparent outlier)
Cadmium, Total	0.98	0.099
Copper, Total	0.94	0.0553
Lead, Total	0.99	0.041
Zinc, Total	0.87	0.49

[1] One way of interpreting r^2 values is that if total copper has an r^2 value of 0.73 with TSS, then TSS explains 73% of the variability of total copper in the data set.

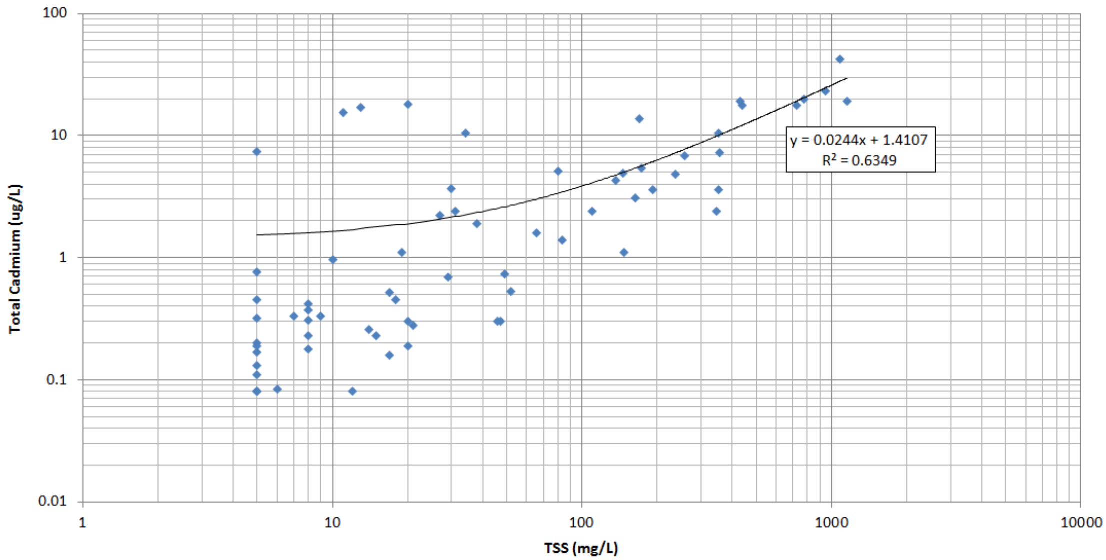


Figure 2-21. Correlation of Total Cadmium with Total Suspended Solids at Fletcher Mine.

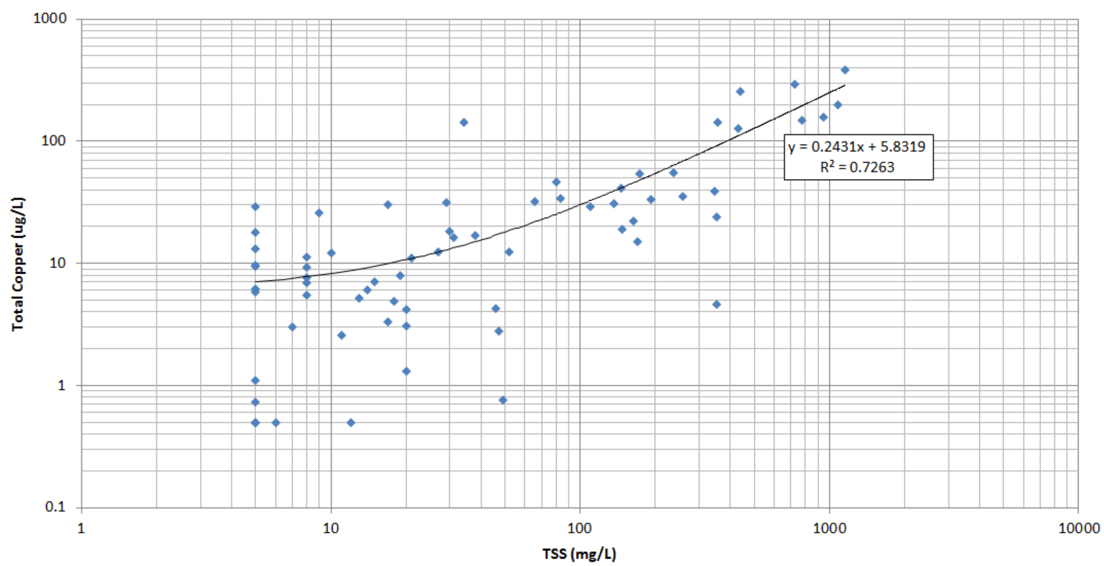


Figure 2-22. Correlation of Total Copper with Total Suspended Solids at Fletcher Mine.

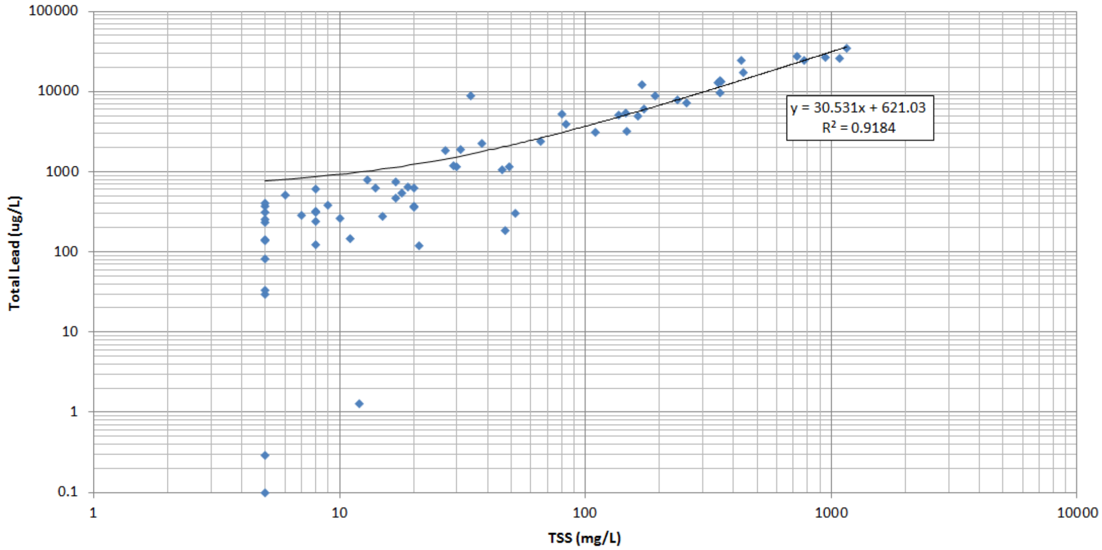


Figure 2-23. Correlation of Total Lead with Total Suspended Solids at Fletcher Mine.

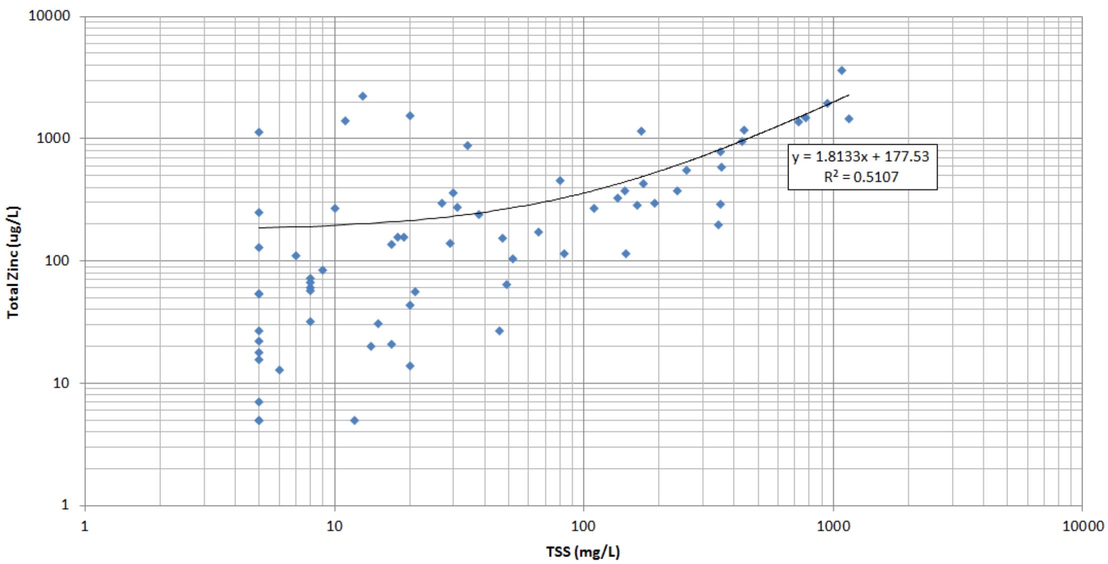


Figure 2-24. Correlation of Total Zinc with Total Suspended Solids at Fletcher Mine.

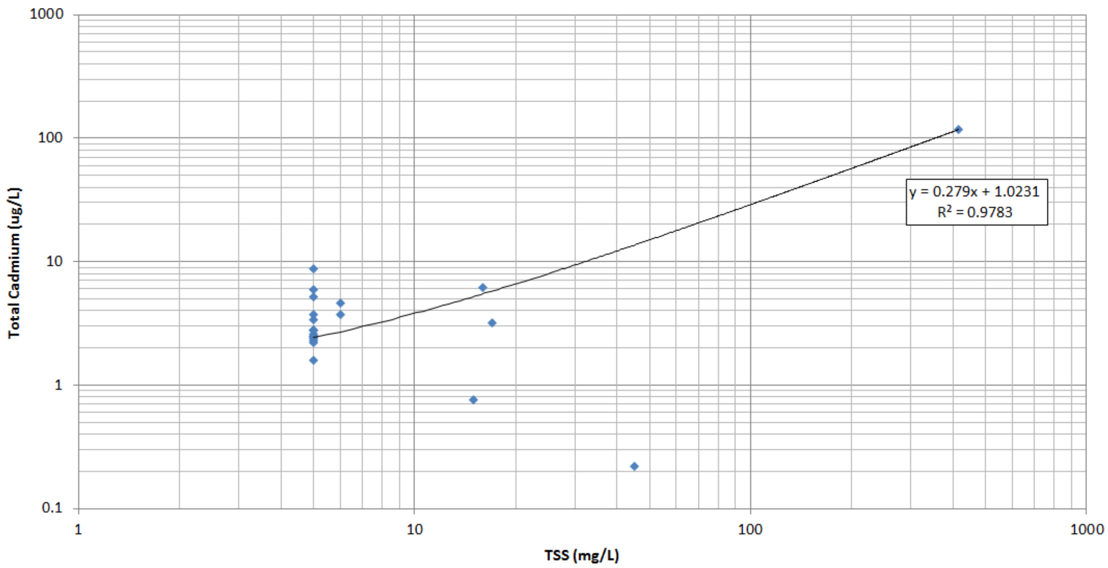


Figure 2-25. Correlation of Total Cadmium with Total Suspended Solids at West Fork Mine.

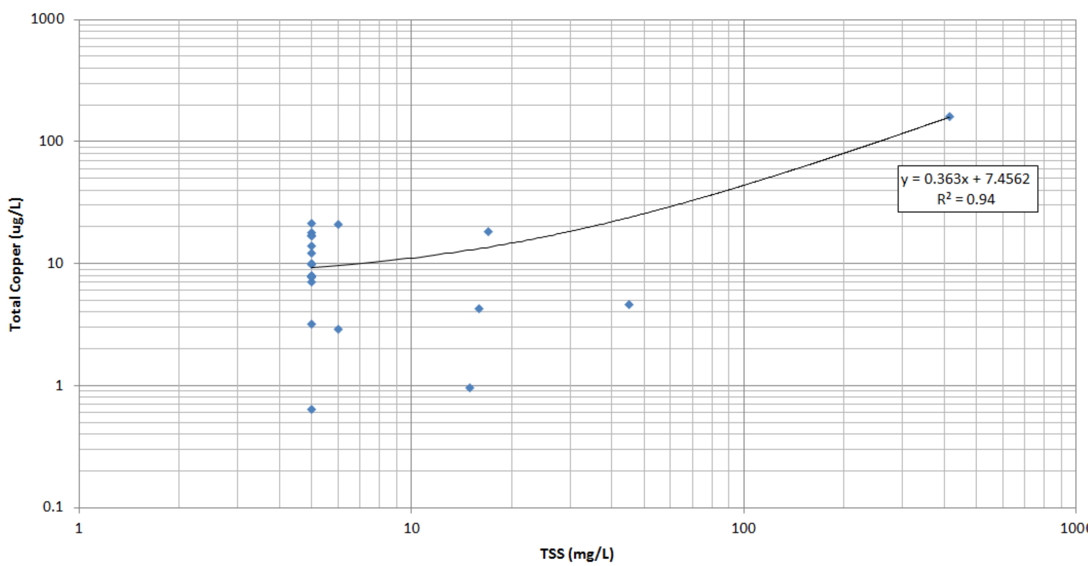


Figure 2-26. Correlation of Total Copper with Total Suspended Solids at West Fork Mine.

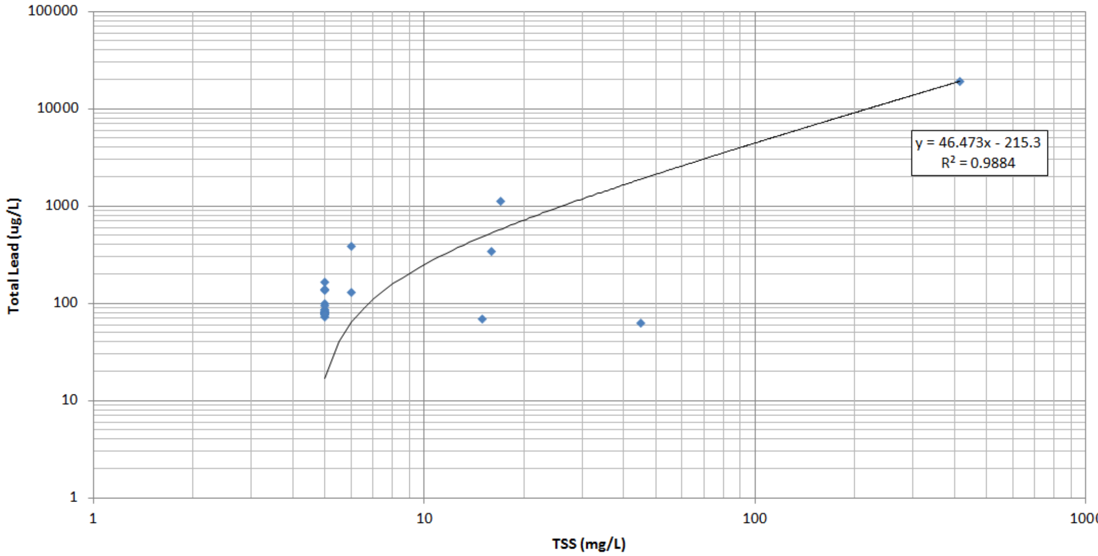


Figure 2-27. Correlation of Total Lead with Total Suspended Solids at West Fork Mine.

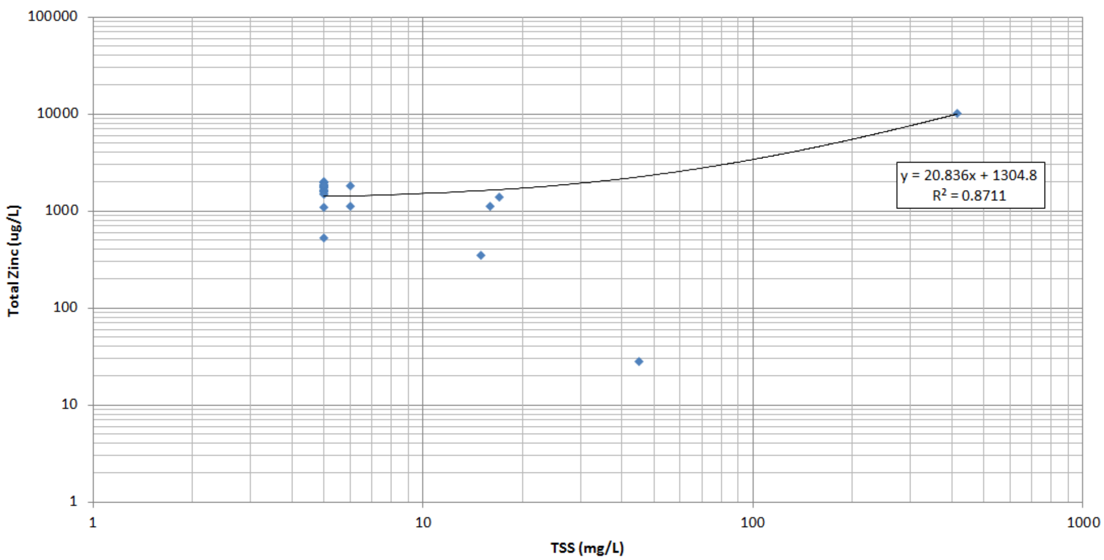


Figure 2-28. Correlation of Total Zinc with Total Suspended Solids at West Fork Mine.

2.2.5 Comparison of Underground and Surface Mine Water

Mine water data collected immediately upstream of the underground sump at Fletcher Mine were compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. Mine water data at the surface is represented by samples taken at the MWLEAK monitoring location, which is located upstream of the mine water basin. The results are plotted in Figures 2-29 through 2-32 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is not possible because the underground and surface samples were not collected on the same dates and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made. Specific observations are as follows:

- Cadmium in the mine sump ditch samples exceeded both the monthly average and daily maximum future final limits in all samples except #8 Pump Sump on 2/8/11. Two of the seven surface samples exceeded the future final monthly average limit.
- Copper results for two of the six mine sump ditch samples exceeded the future final monthly average limits. None of the surface samples exceeded either of the future final limits.
- Lead in the mine sump ditch samples exceeded both the monthly average and daily maximum future final limits in all samples except 8 Pump Sump on 2/8/11. Three of the seven surface samples exceeded both the monthly average and daily max future final limits.
- Zinc concentrations exceeded both the monthly average and daily maximum future final limits in four of the six mine sump ditch samples. One of the seven surface samples exceeded the future final monthly average limit.

Ongoing sampling at Fletcher/West Fork mine will include underground and surface mine water and these data will continue to be evaluated as they become available.

Mine water data collected immediately upstream of the underground sump at West Fork Mine were also compared to mine water samples collected at the surface to evaluate whether the two are comparable in terms of metals content. Mine water data at the surface is represented by samples taken at the FLMineWater location, which is located upstream of the mine water basin. The results are plotted in Figures 2-33 through 2-36 for total cadmium, copper, lead, and zinc, respectively.

Direct comparison of underground and surface mine water is again not possible because the underground and surface samples were not collected on the same dates and it is likely that the mine water varies in quality over time. In addition, there are too few samples for statistical comparison. However some general observations can be made. Specific observations are as follows:

- Cadmium in the mine sump ditch and surface samples exceeded both the monthly average and daily maximum future final limits for outfall 001 in all samples except FLMineWater on 3/23/11.
- Copper results for the mine sump ditch samples and surface samples were below the future final limits for outfall 001.

- Lead in the mine sump ditch and surface samples exceeded both the monthly average and daily maximum future final limits for outfall 001 with the exception of FLMineWater on 3/23/11.
- Zinc in the mine sump ditch and surface samples exceeded both the monthly average and daily maximum future final limits for outfall 001 with the exception of FLMineWater on 3/23/11.

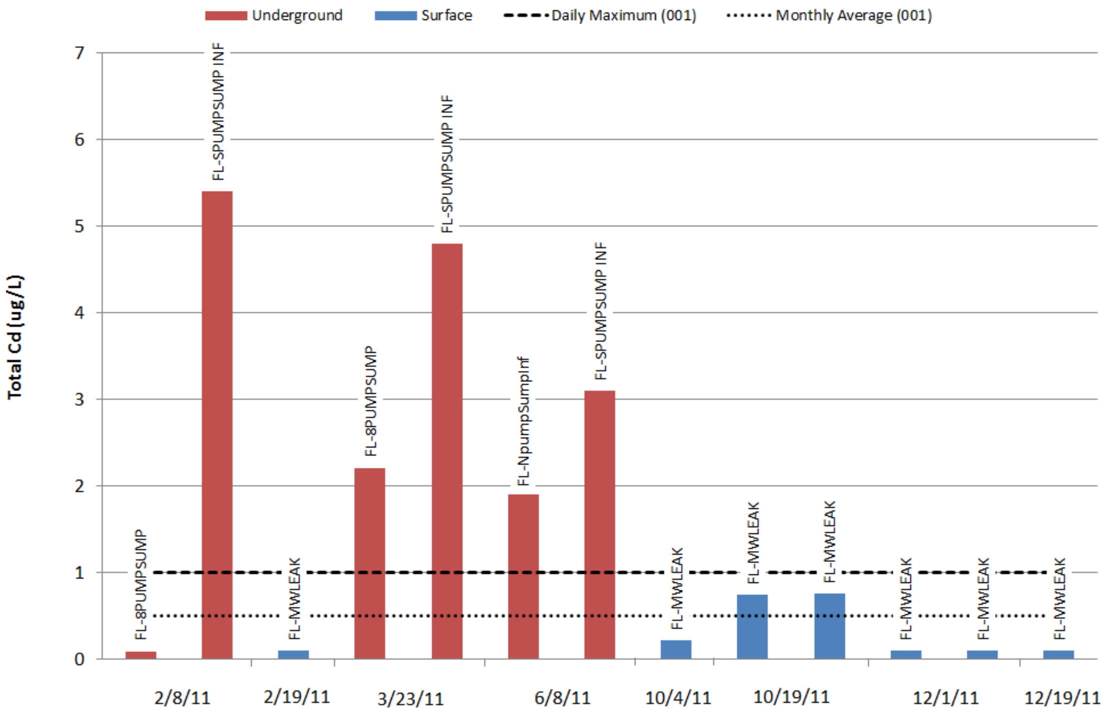


Figure 2-29. Total Cadmium in Underground vs. Surface Mine Water at Fletcher Mine.

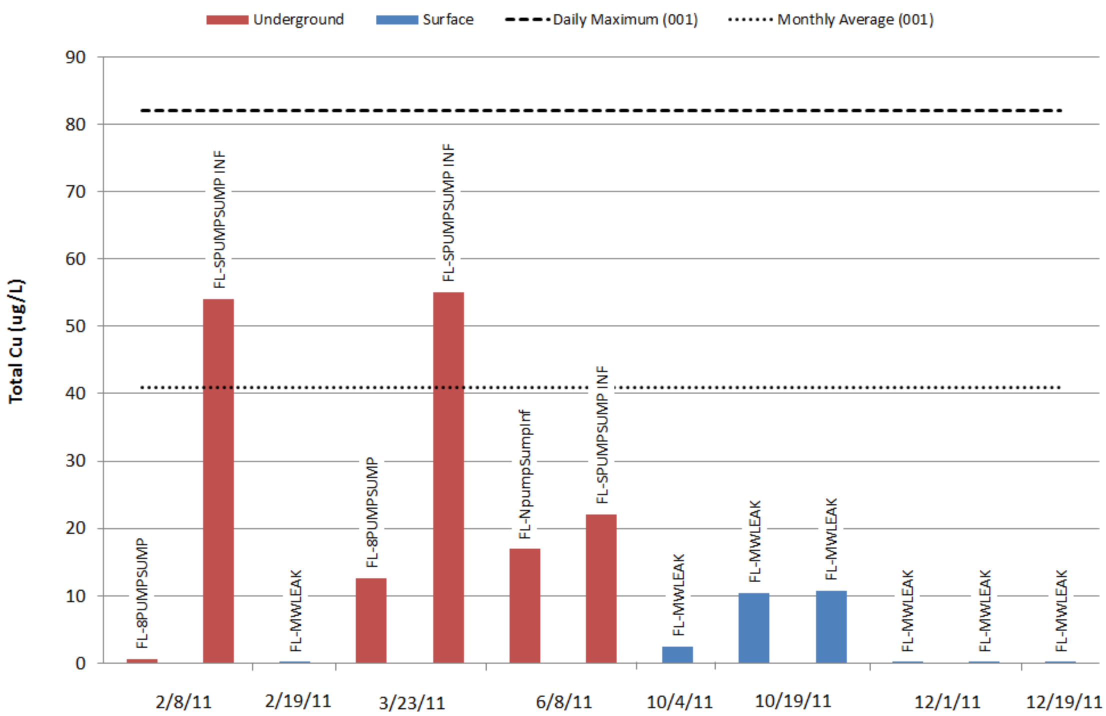


Figure 2-30. Total Copper in Underground vs. Surface Mine Water at Fletcher Mine.

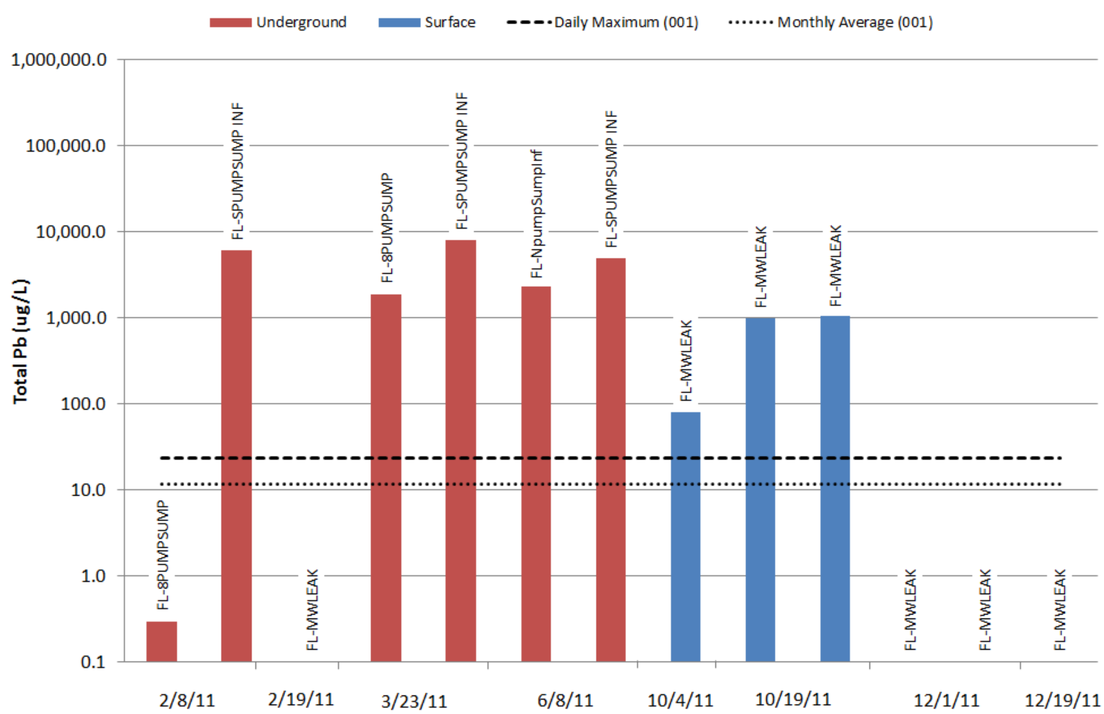


Figure 2-31. Total Lead in Underground vs. Surface Mine Water at Fletcher Mine.

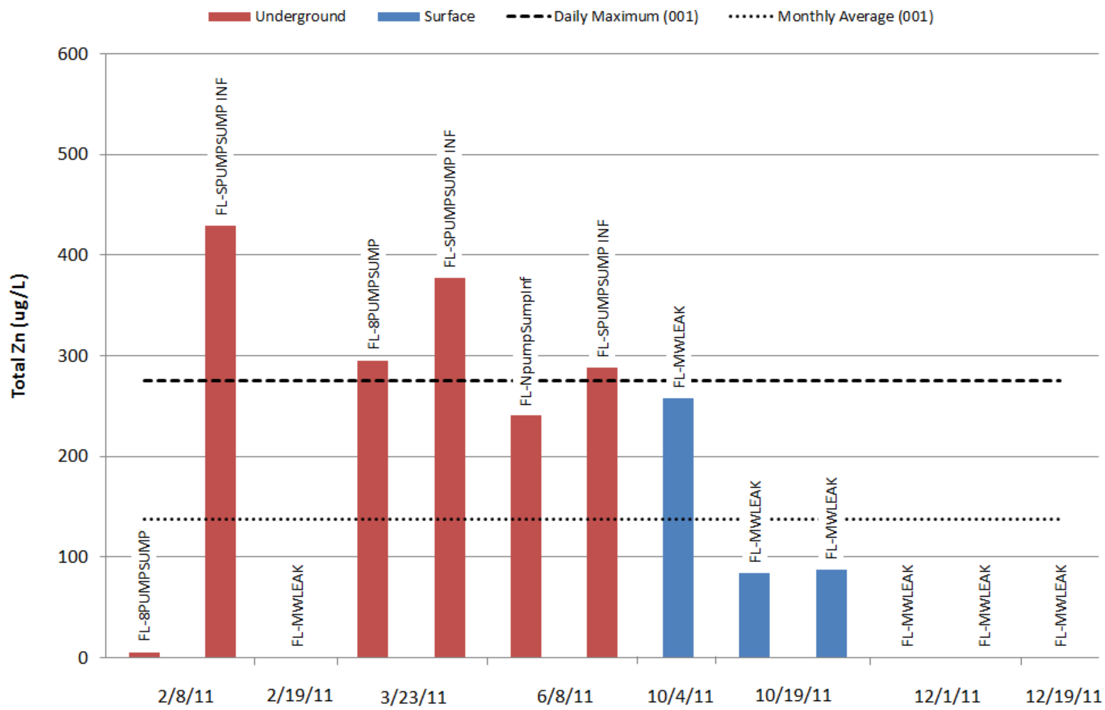


Figure 2-32. Total Zinc in Underground vs. Surface Mine Water at Fletcher Mine.

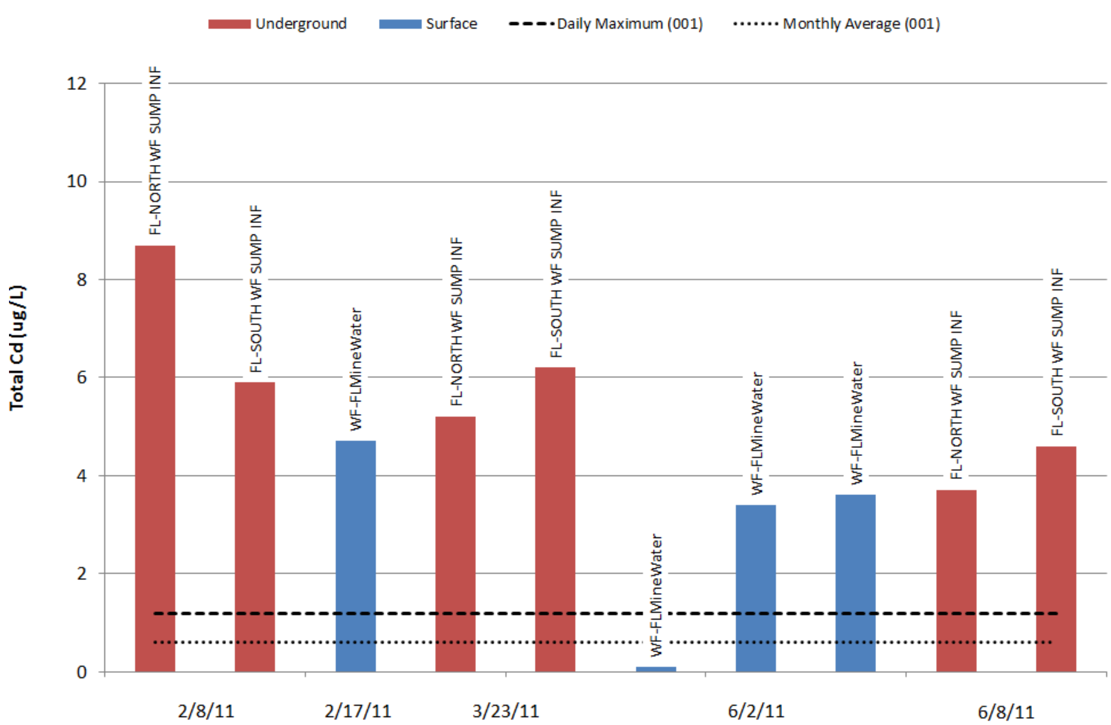


Figure 2-33. Total Cadmium in Underground vs. Surface Mine Water at West Fork Mine.

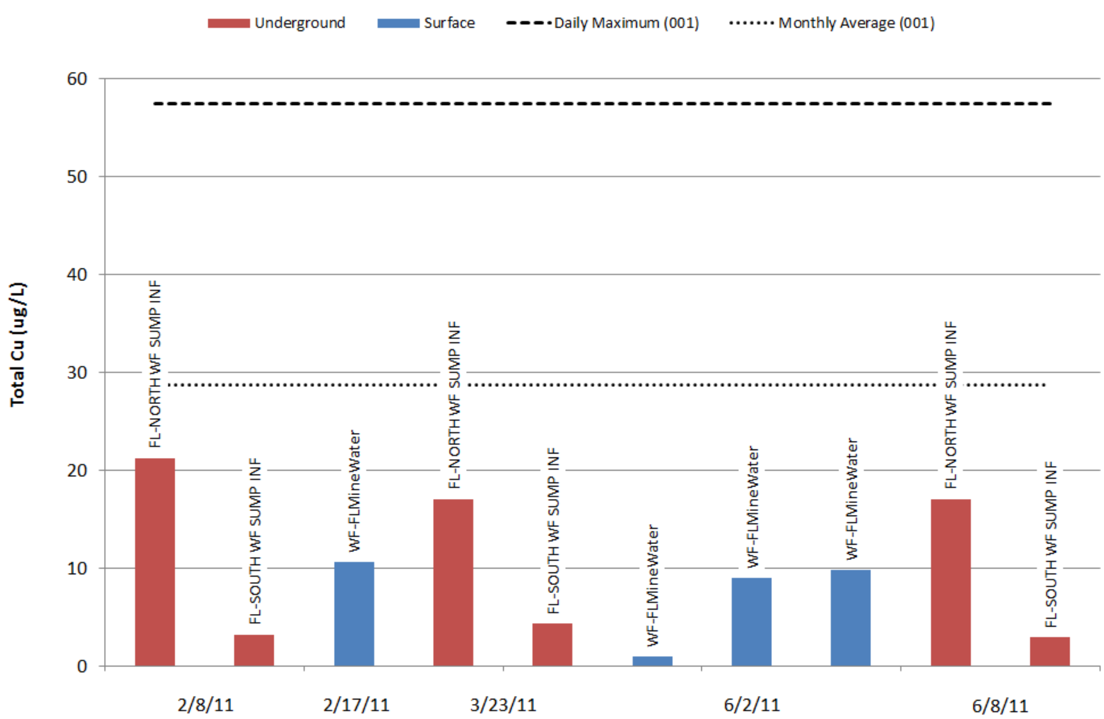


Figure 2-34. Total Copper in Underground vs. Surface Mine Water at West Fork Mine.

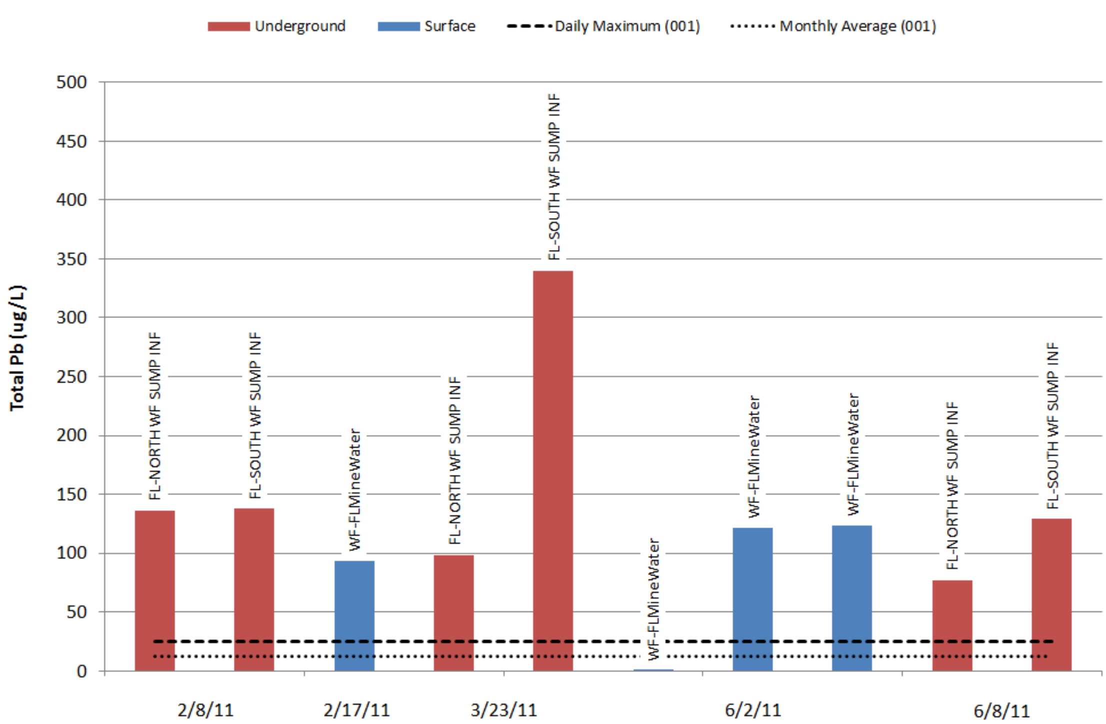


Figure 2-35. Total Lead in Underground vs. Surface Mine Water at West Fork Mine.

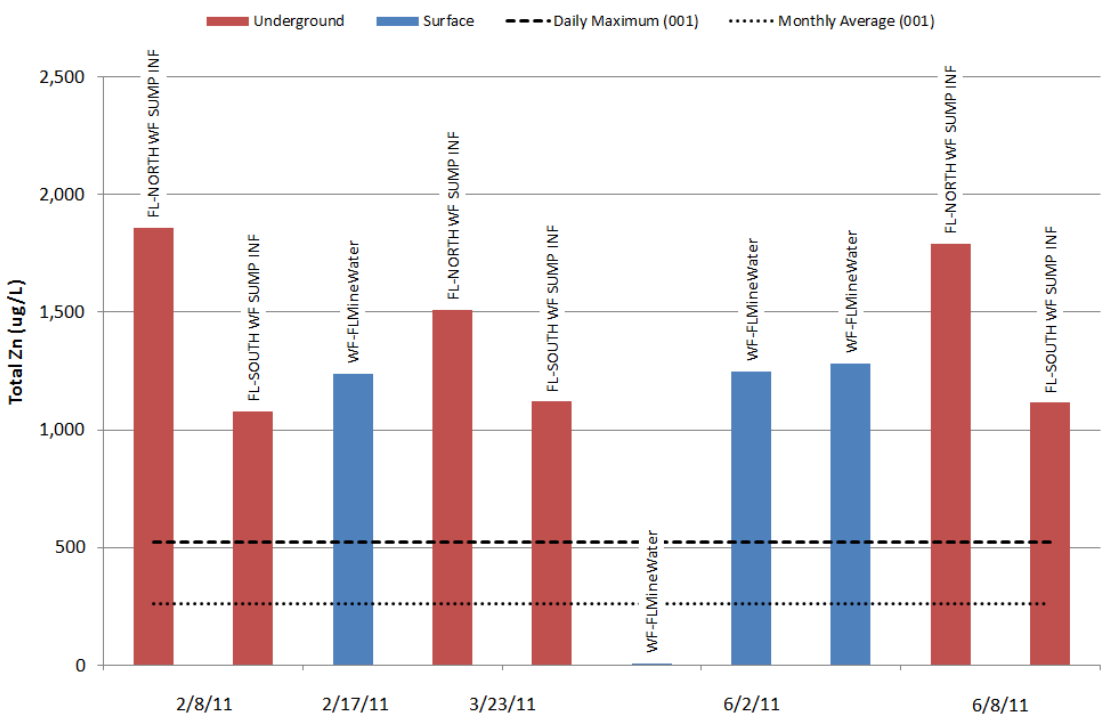


Figure 2-36. Total Zinc in Underground vs. Surface Mine Water at West Fork Mine.

2.3 SUMMARY OF MINE WATER SOURCES AND CONDITIONS

The findings of the preceding discussion of mine water at Fletcher/West Fork Mine can be summarized as follows:

- The average flow of water entering Fletcher Mine and being pumped to the surface is estimated at 4,200 gpm. Of this total mine water flow, approximately eighty percent (3,500 gpm) comes from the south part of the mine. The average flow entering West Fork Mine and being pumped to the surface is estimated at 1,400 gpm. Of this total mine water flow, approximately two thirds (900 gpm) of the flow comes from the north part of the mine.
- Incoming mine water has relatively low metals concentrations, and exposure to the mine workings increases those concentrations.
- Total cadmium, copper, lead and zinc appear to be positively correlated with TSS in mine water at Fletcher Mine. Increased suspended solids in mine water appears to increase total cadmium, total lead, and total copper but does not affect total zinc as strongly. No conclusions can be drawn regarding the relationship between TSS and total metals in mine water from West Fork Mine.

- In general, concentrations of total cadmium, copper, lead and zinc in mine water at Fletcher/West Fork have the likelihood to exceed future final effluent limits.
- Mine water data collected to date indicate that cadmium and zinc tend to be slightly higher in the north part of Fletcher than in the south, while lead and copper concentrations are similar. Copper and zinc tend to be higher in the north part of West Fork than in the south, while cadmium and lead tend to be slightly higher in the south part of the mine than in the north.

Some possible water management approaches for Fletcher/West Fork Mine for consideration as a result of these findings, include:

- Evaluate the effectiveness, technical feasibility and cost-effectiveness of measures that minimize exposure of water entering the mine to mine workings.
- Evaluate options that are effective, technically feasible and cost-effective to minimize the introduction of suspended solids to mine water in an effort to reduce metals concentrations.

These water management approaches were used to evaluate potential water management measures, as discussed in Section 3.

3. WATER MANAGEMENT MEASURES

This section of the plan presents several potential water management strategies and evaluates them in the context of Fletcher/West Fork Mine. In keeping with the Master Underground Water Management Plan, this section discusses the following types of possible measures:

- Isolation measures (Section 3.1)
- Treatment measures (Section 3.2)
- Groundwater interception (Section 3.3)
- Best management practices (Section 3.4)

A summary of the evaluation of these measures for Fletcher/West Fork Mine is presented in Section 3.5. It should be noted that this Section discusses potential underground water management measures and that these measures are not necessarily all planned for implementation at Fletcher/West Fork Mine. Section 4 describes which of these measures are planned for implementation and further evaluation of their effectiveness, technical feasibility, and cost-effectiveness at Fletcher/West Fork Mine. It should also be noted that Doe Run is currently evaluating the technical feasibility and probable costs of treating mine water at the surface and these evaluations will provide a point of comparison with potential underground water management measures to evaluate the cost-effectiveness of those measures.

3.1 ISOLATION MEASURES

Isolation measures are practices designed to isolate mine water from materials/processes that have the potential to increase metals in the mine water. The objective of isolation technologies is to eliminate or reduce the potential for mine water to contact or be exposed to environments that have the potential to increase the metals load.

3.1.1 Piping Water

In some locations in the mine, mine water flows via gravity in roadside ditches. In some places in Fletcher/West Fork Mine, where it is necessary to pump water due to grade changes, the water flows through pipes. In areas where there is open water in ditches and piping is not used, the water surface is exposed to loading of solids and metals from the roadways, mobilized by passing trucks and machinery. Because of this potential exposure, piping presents a potential control measure for improving water quality. A general piping contingency plan is discussed in Section 4.1.2 of this Plan.

Parts of Fletcher/West Fork Mine that are currently piped are shown on the map in Appendix A. Piping used in the mine typically consists of high density polyethylene (HDPE) pipe, with 8-inch and 10-inch diameter (nom.) being the most common size used for long runs in Doe Run mines. The unit cost for these pipe materials ranges from $7 to $10 per linear foot (l.f.) for 8” pipe and $11 to $17 per l.f. for 10” pipe.

These are materials costs based on current vendor pricing and do not include labor for installation.

Review of sampling data from Doe Run mines shows that water quality is reduced within a short distance of water entering the mine. This suggests that, for piping to be an effective control measure, water must be captured very close to the source before significant exposure to mine workings occurs. This is not possible in every circumstance. However, piping may be implemented on a localized basis at the Fletcher/West Fork Mine as a water quality management measure where the company determines that the measure will be effective in controlling water quality and will be cost-effective.

3.1.2 Lined Channels

Roadside channels in the mine allow contact between flowing water and the underlying rock. This contact may cause an increase in metals concentration, so lining of the channels was evaluated. Lining would involve placement and anchoring of an impermeable material on the bottom of the ditch to prevent the water-rock contact. This approach has not been tested but it may be less effective than piping because it only addresses the issues of contact between flowing mine water and underlying rock, whereas piping should isolate mine water from the surrounding mine workings, as well as the underlying rock. In addition, sediment could likely accumulate in the lined channel over time and defeat the purpose of the lining. For these reasons, channel lining is not considered for evaluation as a potential water quality control measure for Fletcher/West Fork Mine.

3.1.3 Work Area Isolation

As described in the Master Underground Water Management Plan, work area isolation includes “isolating or compartmentalizing those areas to prevent the migration of materials into the water conveyance system.” The master plan suggests work areas may be separated from the remainder of the mine by physical measures such as berms, entrance tunnel modifications, or preplanning of new mine area configurations.

The feasibility of these potential measures was discussed with mine personnel. The challenge to implementing these measures is that they will interfere with mining operations. For example, berms placed between drilling or ore loading areas and water drainage channels will interfere with the passage of vehicles. It is impractical to build the berms up and tear them down every time a vehicle or piece of machinery needs to leave the work area. Entrance tunnel modifications and new mine area pre-planning involve designing tunnels so that a high point exists between work areas and the rest of the mine to prevent the drainage of water impacted by mining activities from leaving the work area. This technique is impractical in most cases because the prevention of mine water drainage from work areas will result in flooding of those work areas. For the reasons discussed above, work area isolation is not considered for further evaluation as a possible water quality control measure for Fletcher/West Fork Mine.

3.1.4 Capture of Drill Fines

The Master Underground Water Management Plan also identified the capture of drill fines as a potential control measure. As stated in the Master Underground Water Management Plan, drilling is conducted for both mine development and ore recovery operations and the drilling process produces fines which have the potential to become suspended in mine water. Three types of drilling are used at Fletcher/West Fork Mine:

- Jackhammer drilling is a percussion drilling method used for exploratory drilling in the mine. This is a "wet" drilling technique that generates fine material from the borehole that is carried away from the borehole by water.
- Core drilling is a second exploratory drilling technique that uses water to flush fines away from the core barrel and bit to extract a rock core from the borehole. Drill fines are generated during drilling and carried from the borehole by water.
- Production drilling is a percussion drilling method used during mining operations that can be either air mist or water cooled. Fines are generated in the borehole and carried out of the borehole by water or air.

In general, the quantity of fine materials generated during drilling is relatively small and the water generated during wet drilling is very small relative to other sources of flow in the mine. It is generally infeasible to capture drill fines from any of the above techniques because any method used to capture these fines would substantially interfere with drilling operations. For these reasons, capture of drill fines is not considered for further evaluation as a possible water quality control measure for Fletcher/West Fork Mine.

3.2 TREATMENT MEASURES

One type of underground water control measure considered for improving mine water quality is to actually treat the mine water below ground. Treatment processes that may have the potential to improve the quality of mine water include clarification (settling) and filtration.

3.2.1 Clarification

Clarification is a treatment process that involves the removal of suspended solids from water by gravity settling. Simple clarification typically involves the use of basins or sumps that reduce the velocity of flowing water, which allows a portion of suspended solids to settle. Enhanced clarification usually involves the addition of chemicals to facilitate coagulation and flocculation of fine particles that will not settle on their own. These processes are described below:

- Coagulation is the process of adding chemicals to neutralize particle charges that keep particles dispersed. Once the charges of fine particles are neutralized, they will bind together more readily, forming larger particles. This process is often used when very fine particles are suspended.

- Flocculation is the process of providing suitable conditions for fine particles to bind together and often involves very gentle mixing.

Simple clarification is practiced in the Fletcher/West Fork Mine, in the form of mine water sumps. These sumps are located throughout the mine and act as settling basins. Simple clarification in the form of mine water sumps will be part of the overall mine water management plan for Fletcher/West Fork Mine.

Enhanced clarification using chemicals for coagulation/flocculation, on the other hand, can be a complex process, requiring careful monitoring, with addition of chemicals to adjust the pH of the water being treated for optimization of treatment, followed by readjustment of pH. The process of enhanced clarification results in residuals that are much more difficult to handle and dewater than simple clarification. Providing suitable conditions for settling of the flocculated solids typically requires specialized clarifiers. The challenges of this more complex form of water treatment underground are discussed in Section 3.2.3.

3.2.2 Filtration

Filtration refers to the process of physically separating suspended solids from water by passing the water through material that has openings finer than the suspended materials. This can be accomplished using granular filter materials (e.g., sand filters), woven fabrics, or fabricated plastic or metals filters. The advantage of filtration over clarification is that it results in a more complete separation of water and solids, with the residual solids having lower water content than the residuals of clarification.

Filtration of mine water can potentially be accomplished underground in two ways. First, filters can be used between water sources and water conveyances to remove suspended solids nearer the source. Second, filtration could be used as a centralized treatment process, immediately prior to pumping of mine water to the surface. The use of filtration between water sources and conveyance systems may have potential underground and may be part of the underground water management plan at Fletcher/West Fork Mine. Examples of this are the use of sand berms between flowing coreholes and water collection areas, and filter fabric wrapped around perforated HDPE drainage piping along roadways. Centralized filtration of mine water faces similar challenges as other centralized water treatment processes underground, which are discussed in the following section.

3.2.3 Overall Assessment of Underground Mine Water Treatment Feasibility

Mine water treatment processes, such as filtration between water sources, may be feasible treatment practices for mine water underground. Still, further evaluation is needed to determine the impact of these practices on mine water quality and whether or not they are cost effective. Clarification by means of a centralized mine water sump is currently used at Fletcher/West Fork Mine and will continue to be a part of the overall water management plan. However, other forms of centralized (i.e., large-scale) underground mine water treatment present several challenges, including:

- Available space – Centralized treatment will require a substantial amount of space in the mine. While space is often readily available at the surface, it must be created in the mine by excavating rock. Areas where mining has already occurred are not good candidates because of the possibility that Doe Run may want to return in the future and extract pillars. New areas are expensive to create; the estimated cost of excavating rock underground is $0.60 per cubic foot (c.f.). In order to build only a sump, approximately a half million cubic feet of rock would need to be excavated, and that only includes the space needed to contain the water. In addition, because the same equipment and personnel would be used to excavate the area for treatment as would be used for mining, there is a cost in lost ore production.

- Protection of treatment processes – It would be difficult to prevent treatment processes from being exposed to airborne dust in the mine, which could cause additional metals loading to the treatment system or otherwise upset the processes.

- Specialized operators – The types of treatment that would be required to reduce metals in mine water, aside from simple settling, would likely require trained operators. Such personnel are not currently deployed underground by Doe Run and their deployment underground would be more costly than above ground.

- Management of residuals – One of the biggest challenges for underground mine water treatment is the management of residuals. Although settled materials can be managed using conventional construction equipment, materials settled by flocculation have higher water content and would likely require specialized equipment. In addition, because they are flowable, they would require larger areas for disposal (i.e., they cannot be piled).

The use of mine water sumps for clarification (both distributed throughout the mine and at centralized locations prior to pumping to surface) will be part of the underground water management plan for Fletcher/West Fork Mine. Other types of centralized underground mine water treatment do not appear to be feasible at Fletcher/West Fork Mine because of the challenges outlined above and will not be evaluated further.

3.3 GROUNDWATER INTERCEPTION

Groundwater interception is used here to include all measures that prevent water from entering the mine. Water can enter mine areas in a few ways:

- Coreholes – This refers to exploratory borings advanced from the surface to mine depth or from within the mine into the mine face, used to identify ore locations and direct mining activities. Coreholes sometimes intercept fractures and voids in the rock that convey water and then act as drains to allow water from the rock to enter the mine.

- Access and vent shafts – These are large-diameter shafts constructed from the surface to mine depth to allow access by personnel and equipment, removal of ore, and ventilation of mine areas. Because they intercept overlying aquifers and penetrate aquitards between the overlying aquifers and the mine, they can become major water sources to the mine. Casing is usually installed in these shafts, which greatly reduces flows. Flows into these shafts can also come from storm water at the surface, although this contribution is relatively small compared to other flows.

- Fractures – Rock fractures are naturally occurring and mining activities at Fletcher/West Fork occur in an aquifer to begin with, so it is common for those mining activities to intersect water-bearing fractures. When this occurs, the fractures become a means of water entry into the mine.

The primary methods available to intercept groundwater before it enters the mine are sealing of coreholes and fractures, casing of shafts, and aquifer dewatering to prevent groundwater from entering coreholes, shafts, and fractures.

3.3.1 Corehole and Fracture Sealing

When mining operations intersect coreholes and fractures, they can become a source of water to the mine. This can be true for a surface corehole if the corehole was incompletely sealed after drilling or if the seal has somehow failed over time. The Doe Run standard operating procedure for exploratory coreholes requires that coreholes penetrating the Davis shale must be fitted with an expandable packer within the bottom part of the formation and the hole must be filled with grout to at least 50 feet above the top of the Davis formation. This standard operating procedure remains in effect.

If a leaking corehole is encountered during mining operations, the corehole can sometimes be sealed using mechanical packers or grout. Mechanical packers have historically been used and have been shown to be effective, although in some cases stopping the flow from a corehole has caused the flow to enter the mine elsewhere. Fletcher/West Fork Mine personnel may plug coreholes that yield significant flow when they are encountered during mining. Doe Run has been evaluating the use of chemical grouts. Two types of chemical grout have been tested at the Fletcher Mine with limited results:

- Two-part grout: This is a two-component grout sold under the trade name H2OSTOP and it has been used for high-inflow coreholes. The grout reacts and sets within seconds of mixing, which is accomplished during injection by a static mixer inside a packer that is inserted in the corehole. The grout can expand in volume up to 20:1 and costs about $195 per cubic foot.
- Moisture-reactive grout: This is a single component grout sold under the trade name Hyperflex that sets in contact with water and is used for lower flow applications. This grout can also expand in volume up to 20:1 and costs about $397 per cubic foot.

These grouts can be effective for sealing fractures as well. Vendor information for both of these products is included in Appendix B. There is no reliable way to estimate how much material will be required to grout a corehole. In the last year, an estimated

200 cubic feet of product has been used. Corehole and fracture sealing will be a part of the underground water management plan for Fletcher/West Fork Mine, where it is feasible, technically possible, and cost-effective to do so.

3.3.2 Shaft Sealing/Repair

Because access and ventilation shafts are necessary for the safe and productive operation of the mine, they cannot be eliminated. Although it is not possible to completely seal the shaft to prevent any water from entering the shaft (and therefore the mine), the standard practices employed by Doe Run are usually capable of eliminating most of the flow. These practices involve the installation of casings in the shafts to seal out water. At present, the shafts at Fletcher/West Fork Mine are not a major source of mine water flow. Therefore, shaft sealing/repair is not considered for further evaluation as a significant water quality control measure for Fletcher/West Fork Mine.

3.3.3 Aquifer Dewatering

The only other potential flow reduction measure to prevent water from entering the mine is interception of the groundwater in the aquifer before it reaches the mine. This would require installation of dewatering wells at critical points around the mine, at the depth of the contributing aquifers, and pumping of groundwater from the wells. Implementation of aquifer dewatering is a substantial and costly undertaking that would typically only be evaluated for very large sources of flow. Aquifer dewatering would require the following steps:

- Hydrogeological investigation to fully characterize water-bearing units around and above the mine.
- Installation of pumping wells to test the rates at which water could be pumped from the aquifer and the drawdowns in potentiometric surface that could be achieved.
- Evaluation of the ability of pumped groundwater to meet surface water future final discharge limits.
- Upon completion of the above testing, the dewatering system would be designed and constructed.

One major advantage of this approach is that it involves pumping of groundwater to the surface before it comes into contact with the mine workings. This would presumably eliminate the need for treatment at the surface prior to discharge. It is likely not feasible, however, to use aquifer dewatering for an entire mine, miles in length, due to the costs involved, therefore, aquifer dewatering is not considered for further evaluation as a possible water quality control measure for Fletcher/West Fork Mine.

3.4 BEST MANAGEMENT PRACTICES

There are several underground water management practices that can potentially be used to maintain or improve mine water quality. These are referred to as best management practices (BMPs) and several were identified in the Master Underground Water Management plan, including the following:

- Berms
- Channels
- Collection and Containment of Impacted Water
- Clean Mining Areas
- Material Handling and Storage
- Erosion Control
- Roadway Maintenance
- Maintenance Schedules

In addition, sump cleaning and inspections were identified as BMPs that should be considered. These BMPs are discussed below.

3.4.1 Berms

The use of berms was discussed previously in this plan (Section 3.1.3). Because even temporary berms will interfere with the movement of vehicles and equipment in the mine, where working space is already limited, it does not appear that their use is feasible, except in situations where flows can be directed to inactive mining areas, which is already done at Fletcher/West Fork Mine.

3.4.2 Channels

Shallow channels are already used throughout Fletcher/West Fork Mine to convey mine water flows. As discussed in Section 3.1.2, these channels are already problematic because they expose mine water to more impacts from mine workings. The potential for replacing open channels with enclosed pipes will be discussed in Section 4.

3.4.3 Collection and Containment of Impacted Water

Once water is impacted by exposure to mine workings, it should be isolated from unimpacted water. For example, if impacted water is created at the working mine face during ore extraction operations, it should not be mixed with unimpacted water seeping from coreholes, if this can be avoided.

3.4.4 Clean Mining Areas

In general, maintaining clean mining areas may help reduce the potential for mining activities to impact mine water. This “good housekeeping” practice will be employed to the extent possible in all mining areas and may include storage of ore, drill fines, waste rock, and mining equipment away from areas where water is collected.

3.4.5 Material Handling and Storage

This BMP refers to practices for handling and storage of materials that have the potential to impact mine water quality. This may include stockpiled ore or it may include solids removed from sumps during mucking. The practice for storing such material stockpiles will be that they are placed so as to minimize impacts to mine water.

3.4.6 Erosion Control

As described in the Master Underground Water Management Plan, erosion control in mines includes the protection of any surface that has the potential to erode and increase the loading of suspended solids. These areas include material storage piles and transportation corridors. At Fletcher/West Fork Mine, erosion control of storage piles will be addressed by material handling and storage practices and erosion control of transportation corridors will be addressed to the extent feasible by the roadway maintenance program.

3.4.7 Roadway Maintenance

The heavy traffic of trucks and mining equipment over mine roadways, which are normally constructed of crushed rock, can result in erosion of the road surface. This can have two related impacts on mine water quality. First, the erosion of road materials can move fine materials into roadside channels filled with water. Second, the erosion can result in a lowering of the road bed over time, which can eventually lead to flooding of the eroded part of the road. Regular inspection of roadways and prompt repair of eroded areas will be part of the underground water management plan for Fletcher/West Fork Mine.

3.4.8 Maintenance Schedules

Scheduling of maintenance activities related to underground water management at Fletcher/West Fork Mine will be driven by monitoring and inspection activities, as discussed in Section 4.

3.4.9 Sump Cleaning

At Fletcher/West Fork Mine, like all Doe Run mines, mine water flows via gravity and/or pumping to central sumps where it is then pumped to the surface. There are currently three main mine water sumps at Fletcher Mine: North Main Sump, South Main Sump and #8 Sump. A West Fork, there is one main mine water sump, simply referred to as the West Fork Sump.

All mine water sumps provide temporary storage for mine water and, as a result, can have potential for settling solids, proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids, by design. This means, however, that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, accumulated solids could eventually impair pumping. For these reasons, periodic maintenance of the sumps is required to remove solids. The process of sump cleaning is referred to as “sump mucking.”

Sump mucking involves temporarily draining the sump, then mechanically removing the accumulated solids from the sump. The solids are transported to an inactive area of the mine for storage, where they dewater by gravity drainage. Since they consist of fine rock and ore, the dewatered solids are sometimes added to the mined materials sent to the surface for processing.

Experience at Doe Run mines shows that sump cleaning results in excessive wear on the machinery that is used to remove the accumulated solids because the fine solids get into the mechanical and hydraulic components of the machinery and are abrasive. Significant costs can be incurred for equipment refurbishment after every sump mucking event. Because sump cleaning is a necessary component of mine operations, it will be continued in the future and is discussed further in Section 4.

3.4.10 Inspections

Regular inspection of mine water management measures will be an important part of the overall underground water management plan at Fletcher/West Fork Mine. These inspections will be used to monitor effectiveness of the plan and to identify the need for maintenance of roadways, piping, sumps, and other mine water management measures.

3.5 SUMMARY OF WATER MANAGEMENT MEASURE EVALUATION

Several potential water management measures have been identified for the Fletcher/West Fork Mine as they may have the potential to reduce mine water flows and improve water quality. The measures are summarized in Table 3-1 along with notation on which will be part of the Fletcher/West Fork underground water management plan. In all cases, the use of the measures discussed here will be evaluated and implemented if Doe Run determines that the measures are effective, technically feasible, and cost effective, or will be further evaluated for potential implementation.

Table 3-1. Summary of Water Management Measure Evaluation for the Fletcher/West Fork Mine.

Type of Measure	Measure	Assessment Summary	Included in Fletcher/ West Fork UGWMP?
Isolation	Piping	Potentially effective on a localized basis; to be evaluated further	Yes
	Channel lining	Not an effective control measure	No
	Work area isolation	Not feasible	No
	Capture of drill fines	Not feasible	No
Treatment	Clarification	Simple settling feasible; enhanced clarification infeasible	Yes
	Filtration	Potentially feasible on a localized basis; may undergo further evaluation	No
Groundwater Interception	Corehole/fracture sealing	Considered on an as-needed basis	Yes
	Shaft repair/sealing	Not needed	No
	Aquifer dewatering	Not part of plan, pending outcome of investigations at Sweetwater Mine	No
Best management practices (all to undergo regular review and evaluation)	Berms	Useful in some case	Yes
	Channels	Necessary, piping preferred in some areas	Yes
	Collection/ containment	Potentially useful	Yes
	Clean mining areas	Potentially useful	Yes
	Material handling/storage	Potentially useful	Yes
	Erosion control	Addressed by material handling & roadway maintenance	No
	Roadway maintenance	Potentially useful	Yes
	Maintenance schedules	Necessary, driven by monitoring and inspections	Yes
	Sump cleaning	Necessary	Yes
	Inspections	Necessary	Yes

This page is blank to facilitate double sided printing.

4. PLAN ELEMENTS AND IMPLEMENTATION

The underground water management plan for Fletcher/West Fork Mine is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of potential measures focusing on cost-effectiveness and impact on water quality;
- Development of planned actions;
- Implementation of planned actions;
- Monitoring of implemented actions (data collection and inspection);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Fletcher/West Fork Mine plan discussed in this section are:

- Water management actions
- Best management practices
- Monitoring
- Inspection
- Recordkeeping
- Training
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections. It should be noted that mine water treatment evaluations are ongoing at Doe Run. The outcome of these evaluations will determine the most effective mine water treatment method, as well as an accurate estimate of the unit cost for mine water treatment. This will allow evaluation of potential underground water control measures in the context of relative cost-effectiveness, compared to treatment at the surface. Based on these comparisons, some of the measures discussed in this section may be determined not to be cost effective and may be removed from the plan in the future.

4.1 WATER MANAGEMENT ACTIONS

Based on the review of mine data discussed in Section 2 and the evaluation of potential control measures discussed in Section 3, existing practices, procedures, and planned projects are generally appropriate for underground water management at

Fletcher/West Fork Mine. In addition, two contingency plans will be set up for the Fletcher/West Fork Mine to address future potential opportunities for water management actions: corehole sealing contingency and piping contingency. These are described below.

4.1.1 Corehole Sealing Contingency Program

Coreholes do not currently contribute the majority of influent mine water at Fletcher/West Fork Mine. It was noted, however, during the recent data collection effort, that water flowing into the mine from the "Old Powerline Hole" had relatively high lead concentrations. Doe Run personnel plan to plug this hole in the future. Because other flowing coreholes may be encountered as mining proceeds, a corehole sealing contingency program will be implemented. This contingency program will include a standard operating procedure and decision framework for determining which coreholes will be sealed. New coreholes that are encountered during mining operations that produce significant flows to the mine may be sealed, if sealing is technically possible and cost-effective. If possible, the following procedure will be followed:

- Flowrate from the corehole will be estimated by measuring the time required to fill a 55-gallon drum or other similarly-sized container of known volume. If it is not possible to measure the flowrate from the corehole in this manner due to the location of the corehole and difficulty in positioning the container under the stream of flow, a 5-gallon bucket or similar smaller container shall be used. If this is also impractical due to the very small quantity of flow or for safety reasons, the underground water management team will discuss alternate flow estimation methods. Because flows from newly encountered coreholes sometimes vary, the flow will be measured once a month for three months.
- The diameter of the corehole will be measured to the nearest inch. If it is impossible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.
- After measuring the flow and the corehole diameter, the underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past. If the underground water management team is not certain whether sealing is feasible, they will consult with manufacturer's representatives for mechanical plugs and grouts to help determine the feasibility of sealing the corehole.
- If it is determined that the corehole can be sealed, the underground water management team will determine a schedule for sealing that takes into account the priority of the action relative to other water management measures.

The above process is documented in the form of a standard operating procedure, included in Appendix C. Corehole sealing will be documented in writing. The methods and procedures used for sealing will be documented, along with problems encountered and apparent success of the sealing, for future reference.

4.1.2 Piping Program

No piping projects are currently planned for the Fletcher/West Fork Mine for the sole purpose of addressing water quality. However, future circumstances may warrant consideration of piping to address water quality, so a contingency program for piping will be maintained as part of this plan.

Data collected at Doe Run mines indicate that the quality of mine water entering mines can be degraded within a short distance of the point of entry. Therefore, before piping to maintain water quality, the underground water management team will continue to determine whether the piping can be installed in a cost-effective manner and in such a way as to capture the incoming water with a minimum of water quality degradation. This will likely be accomplished by containing the water at the point of entry with a sump or other system and piping directly from the sump to a main mine water sump.

If the source of the incoming water is a corehole, the procedures outlined in Section 4.1.1 will be followed before piping is evaluated. If the source of the water is a corehole that cannot be sealed, the underground water management team will use the following protocol to determine whether piping will be installed:

- The physical setting and surroundings of the source will be assessed by the underground water management team to identify options for containing the incoming flow as close to its source as possible. This process will consider quantity of flow, space availability, accessibility of the source, other mine operations, cost, and safety.
- Once the most feasible and cost-effective option for containing the flow is determined, the underground water management team will determine the flow path the water will follow to reach the containment area. Water samples will then be collected at the end of that flow path, at the point where water would enter the containment area, as well as the point of entry to the mine (i.e., the corehole, fracture, or shaft). This water sampling will follow the standard procedures for sampling that are currently in place for water sample collection.
- The sampling results will be compared to the results for the incoming water as a measure of the water quality degradation that will occur along the flow path to the location of the containment. The results will also be compared to water quality data from the mine water sump to which the water would be piped. The underground water management team will use these comparisons to determine whether the piping is likely to provide a significant water quality benefit and whether the piping is cost-effective.

All data collected during piping evaluations will be recorded. Upon review of new data in the future, if a piping project is determined to be ineffective, the piping project may be terminated or, if already installed, the piping may be removed for use elsewhere.

4.1.3 Ongoing Water Management Measure Evaluations

In addition to the corehole sealing and piping contingency programs described above, the following additional actions will be considered on an as-needed basis:

- Additional piping – As mine expansion occurs, significant inflows of relatively clean groundwater may be encountered and, in some cases, it may be feasible and cost-effective to contain the water locally and pipe it directly to mine water sumps. This measure will be evaluated by the water management team on a case-by-case basis.
- New corehole sealing techniques/materials – The water management team will continue to evaluate new techniques or materials for corehole sealing, as they become available.
- New mine water pump shafts – As mining operations progress, it may become feasible to construct new pump shafts to the surface, as an alternative to moving water from newly mined areas to existing mine water sumps. This will be evaluated by the water management team on an as-needed basis.
- Mine expansion – During mine expansion activities, mine personnel will consider water management strategies from a water quality, as well as logistical, perspective and identify environmentally-appropriate water management strategies into the expansion design.

As with the planned activities described in the preceding section, control measure evaluations will be documented in future updates to this plan.

In addition to the contingency actions outlined above, best management practices, as described in Section 4.2, will be used to manage water quality.

4.2 BEST MANAGEMENT PRACTICES

Several BMPs will be implemented at Fletcher/West Fork Mine as part of this plan, as described in the following sections. Some of these BMPs, such as berms, channels, collection, and clean mining areas will likely be used relatively infrequently because of their limited applicability. Others, such as roadway maintenance and sump cleaning will be performed more frequently, but still on an as-needed basis. BMPs and the conditions where they may be useful will be discussed during personnel training.

4.2.1 Berms

Berms are low barriers used to direct flowing water in a desired direction, away from its natural course. Although the use of berms to contain water within work areas is infeasible due to interference with mining activities, as described in Section 3.1.3, berms may be useful in areas of the mine where active mining and hauling is not occurring. Berms may be considered a potential water management practice in areas where they will not interfere with mining.

4.2.2 Channels

Channels are shallow watercourses, usually along roadways, in the mine. Although allowing water to flow uncovered in channels has been identified as a source of water quality degradation, there may be situations where construction of channels will be useful. For example, as with berms described above, channels may be useful in diverting flow away from main mine water sumps towards unused or inactive areas of the mine. In such situations, a simple open channel might be used or a combination of channel and pipe may be used, where the diverted flow has to cross a roadway.

4.2.3 Collection/Containment

Collection or containment may be used, where feasible and cost-effective, in situations where water impacted by mining activities is in proximity to sources of relatively unimpacted water. Possible collection/containment techniques may include:

- Construction of a local sump to collect the impacted mine water or the unimpacted water source for pumping.
- Use of diversion channels or berms to direct the flow of impacted mine water away from the source of unimpacted water.

The appropriate method of collection or containment will be determined on a case-by-case basis. In situations where the unimpacted water source is a newly discovered corehole, the procedure for evaluating corehole sealing will be followed.

4.2.4 Clean Mining Areas/Material Handling and Storage

The “Clean Mining Areas” and “Material Handling and Storage” BMPs discussed in Sections 3.4.4 and 3.4.5 are combined here because they are closely related. This combined BMP refers to maintaining work areas in the vicinity of open mine water in such a way as to minimize the potential for water quality degradation. This is especially relevant to areas around sumps and around channels that have not been piped. Where possible, stockpiled materials such as ore and waste rock should be located to minimize impacts to water. Equipment should also be stored away from water where possible.

4.2.5 Roadway Maintenance

Roadways will be inspected on a regular basis by mine supervision personnel and any significant repairs will be documented. These inspections will be specifically directed at identifying roadway conditions that might contribute to water quality degradation including, but not necessarily limited to, the following:

- eroded sections of the roadway that are likely to contribute to the degradation of mine water quality (repaired by filling to an acceptable grade)
- broken or plugged drain pipes (repaired by replacing broken pipe or clearing plug)

- water entering from the back and falling onto the road causing erosion (repaired by suspended curtains of suitable material over the roadway to divert falling water to ditches)

It should be noted that there may be cases where a low point in a roadway exists because it is the low point of the mine tunnel and not necessarily due to erosion. In such cases, filling may create insufficient clearance between passing trucks and the back, so repair is not feasible. When appropriate, significant problems and repairs will be logged in the Doe Run Enterprise Task Management System (ETMS).

4.2.6 Maintenance Schedules

Maintenance related to underground water management at Fletcher/West Fork Mine will be performed on an as-needed basis. Regularly scheduled inspections may identify additional maintenance needs.

4.2.7 Sump Cleaning

Fletcher Mine has three main mine water sumps, located very near each other, referred to as the North Main Sump, the South Main Sump and #8 Sump. The North Main Sump and #8 Sump were cleaned in 2011 and cleaning of the South Main Sump was completed in June 2012. Prep work was started in October for cleaning the West Fork Sump. As with other Doe Run mines, the Fletcher/West Fork Mine sumps will be inspected quarterly, starting in July 2012, as part of the routine water management inspection program at Fletcher/West Fork Mine.

If it is logistically feasible, the main mine water sumps at Fletcher/West Fork Mine will be equipped with a sonar depth finder capable of measuring the depth to the sediment/water interface. If this equipment can be installed, a decrease in water depth of 50% at a point in close proximity to the pumps will be used to trigger sump cleanout. This level of fill is based on the experience of mine personnel. As described below, the main mine water sump will be sampled on a regular basis and these data will be evaluated along with the level of accumulated sediment to determine whether a different level should be used to trigger sump cleaning. A standard operating procedure for monitoring sediment levels in main mine water sumps is included in Appendix C.

4.3 MONITORING

Ongoing underground water quality monitoring will be continued at the Fletcher/West Fork Mine to improve the understanding of mine water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 4-1 will be sampled, unless it is determined by Doe Run that an adequate amount of data has been collected.

Table 4-1. Underground Water Sampling Locations for the Fletcher/West Fork Mine.

Location	Sample ID Previously Used	Rationale
10 Vent	FL-10VENT	Monitor incoming water quality
65W30	FL-65W30	Monitor incoming water quality
Mine water to Fletcher North Main Sump	FL-NPUMPSUMP	Monitor water quality entering North Main Sump
Mine water to Fletcher South Main Sump	FL-SPUMPSUMP	Monitor water quality entering South Main Sump
Mine water to Fletcher #8 Sump	FL-8SUMPINF	Monitor water quality entering #8 Sump
South development as it advances	FL-RCWF65	Monitor incoming water quality
North WF	FL-20VENT	Monitor incoming water quality
Mine water to West Fork Sump from south	FL-SOUTHWFSUMPINF	Monitor water quality entering WF Sump from south
Mine water to West Fork Sump from north	FL-NORTHWFSUMPINF	Monitor water quality entering WF Sump from north
South WF	FL-18VENT	Monitor incoming water quality

Continued monitoring was initiated in April 2012, and has typically been conducted on a monthly basis. The results of the continued monitoring efforts are presented in Figures 4-1 through 4-5. Evaluation of the most recent data indicated that underground water quality should continue to be monitored. Therefore, underground sampling for metals and total suspended solids will continue in order to assess changes in water quality underground. Monitoring frequency, locations, and parameters may be adjusted or discontinued, if deemed necessary by Doe Run.

In addition to the monitoring regime described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for underground water management at Fletcher/West Fork Mine.

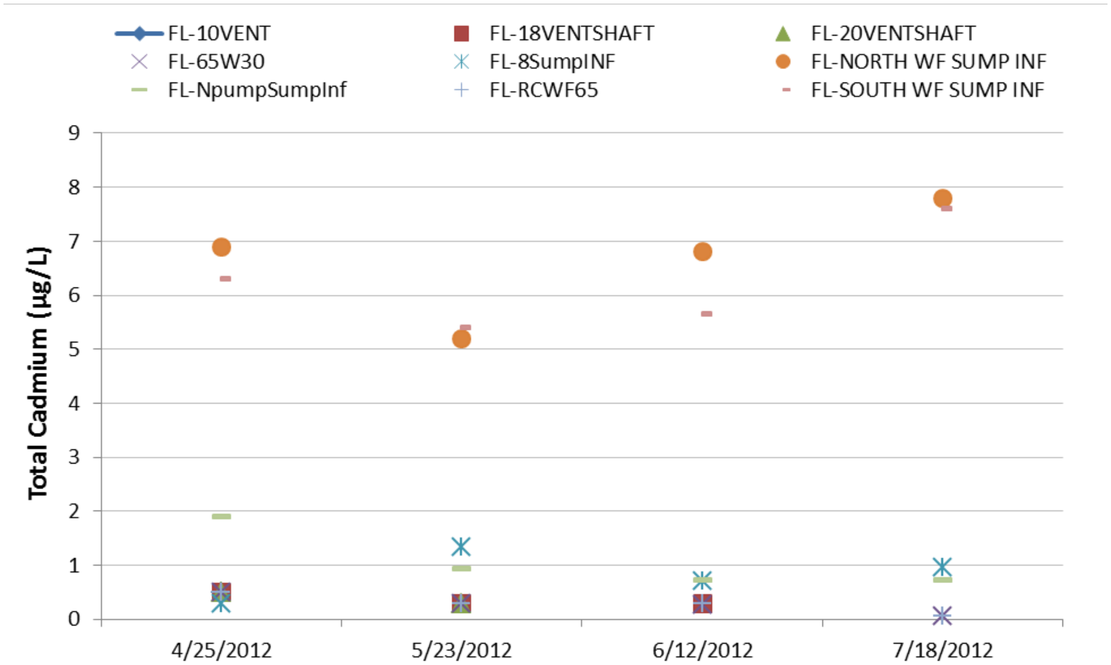


Figure 4-1. Continued Monitoring of Total Cadmium in Underground Sampling Locations at Fletcher/West Fork Mine.

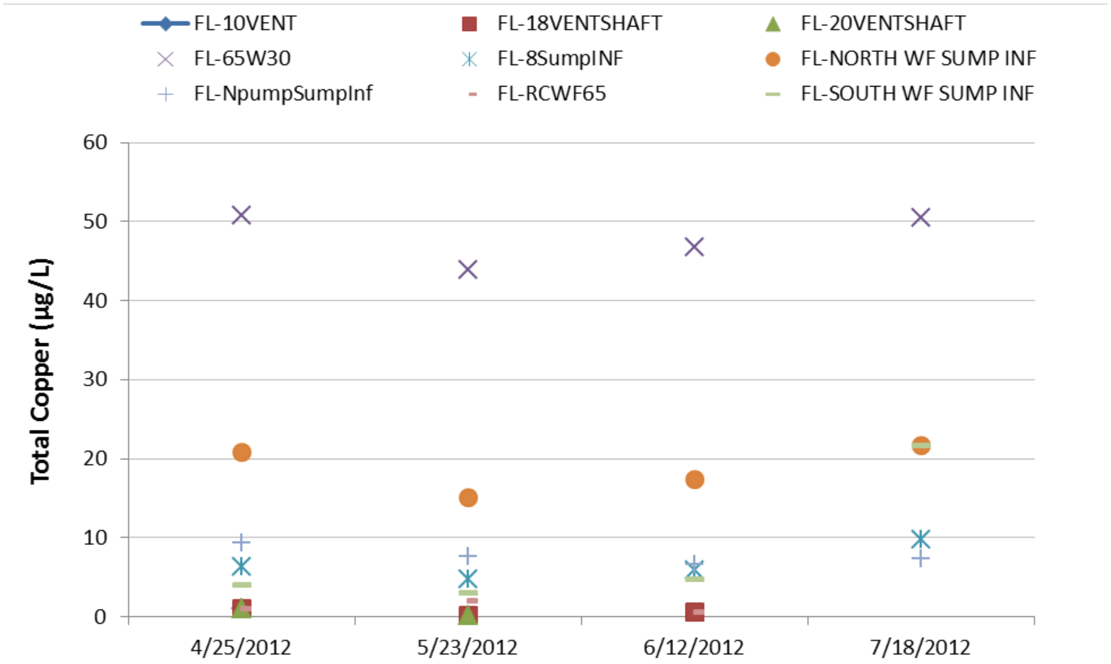


Figure 4-2. Continued Monitoring of Total Copper in Underground Sampling Locations at Fletcher/West Fork Mine.

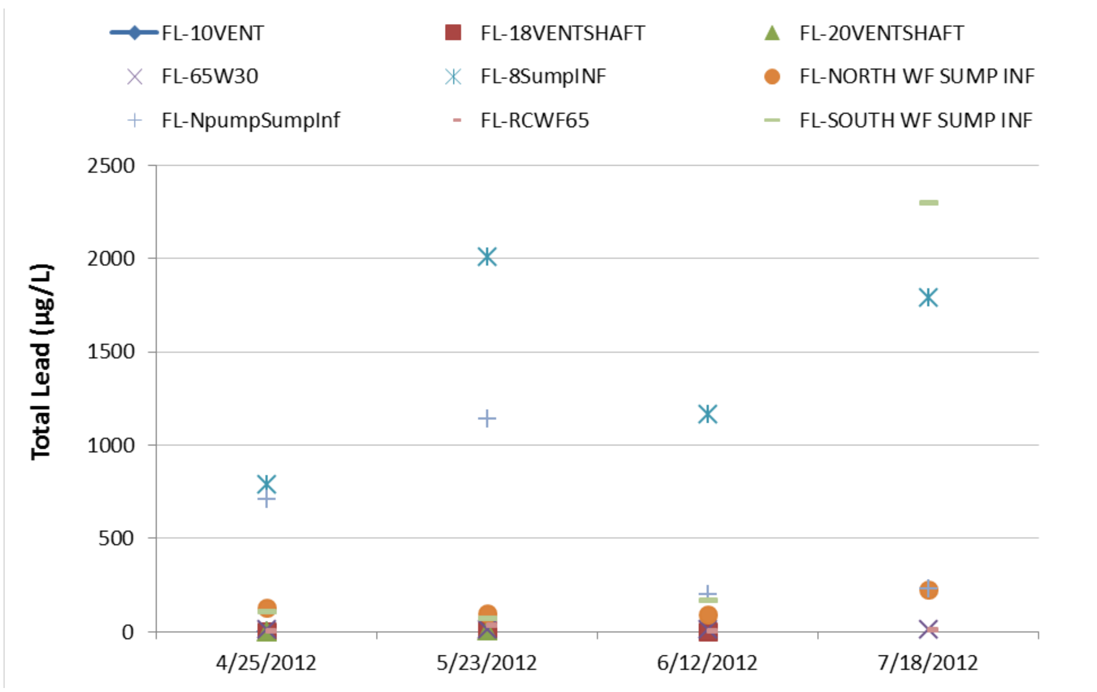


Figure 4-3. Continued Monitoring of Total Lead in Underground Sampling Locations at Fletcher/West Fork Mine.

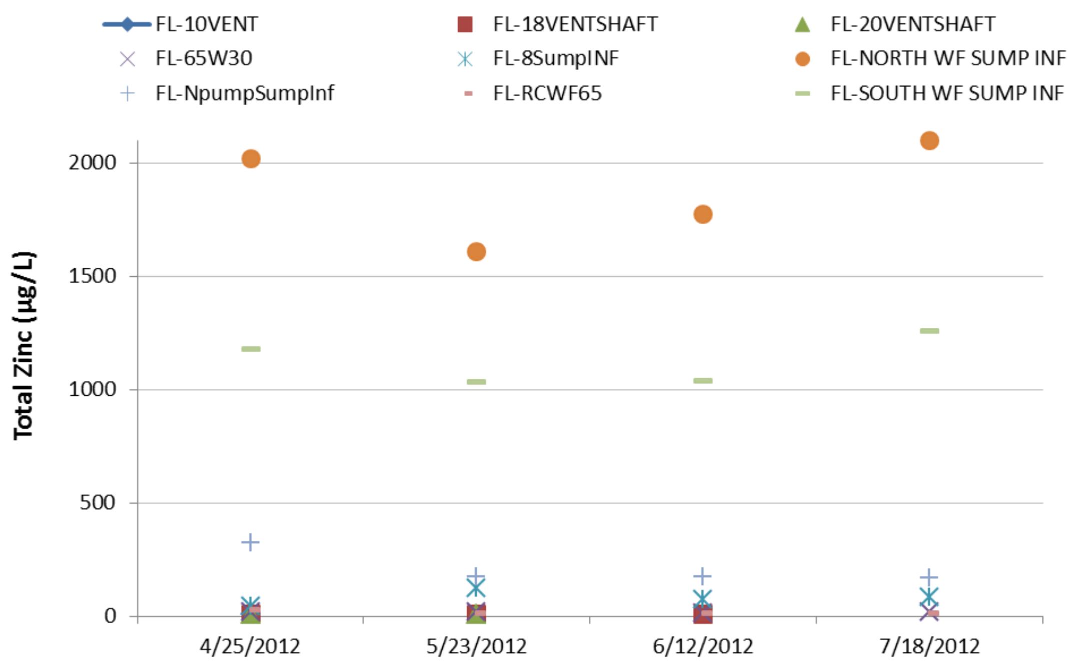


Figure 4-4. Continued Monitoring of Total Zinc in Underground Sampling Locations at Fletcher/West Fork Mine.

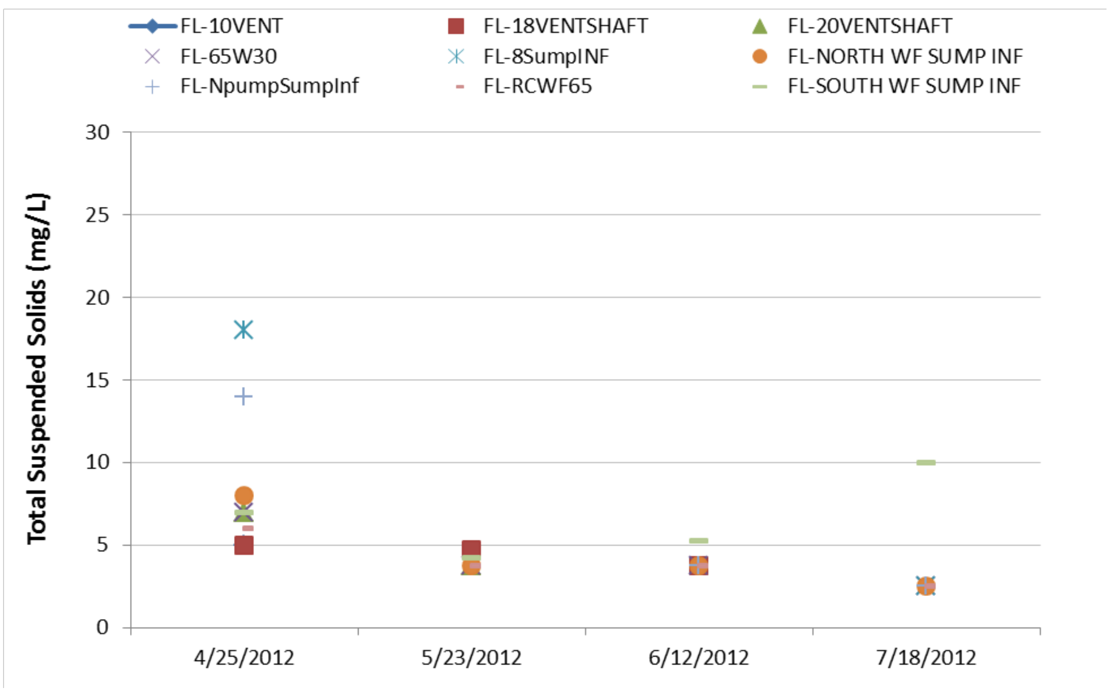


Figure 4-5. Continued Monitoring of Total Suspended Solids in Underground Sampling Locations at Fletcher/West Fork Mine.

4.4 INSPECTIONS

Underground water management inspections will be conducted at Fletcher/West Fork Mine on a quarterly basis, to monitor effectiveness of water management measures and to identify the need for maintenance. Inspections will include visual inspection of the following:

- Main mine water sump to visually assess turbidity and general condition;
- Water piping, to identify leaks;
- Roadways, to identify the need for maintenance;
- Material and equipment storage areas to identify the need for improved separation from sources, conveyances, and sumps;
- Coreholes and/or fractures scheduled for sealing between the previous and current inspections, if any, to verify that sealing has occurred and was effective;
- Sources of water identified since the previous inspection; and
- Any other water management actions undertaken since the last inspection.

Inspections will be conducted by trained personnel (see Section 4.5). All inspections will be documented using the form in Appendix D, which will include the name and signature of the person performing the inspection.

4.5 TRAINING

Training was identified in the Master Underground Water Management Plan and will be an important part of the plan for Fletcher/West Fork Mine. Initial training will be provided by June 30, 2012 to all personnel involved in the management of water at Fletcher/West Fork Mine including, but not necessarily limited to:

- Mine supervision
- Mine engineers
- Technical service personnel
- Environmental technicians

In addition to the initial training for these personnel, annual refresher training will be conducted.

The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for underground water management (including the environmental need);
- Best management practices to be used throughout the mine;
- Specific water management actions being implemented or planned;

- Water management protocols and standard operating procedures;
- Inspections;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

4.6 TRACKING/RECORD-KEEPING

Water management measures will be inspected at Fletcher/West Fork Mine quarterly and the inspections will be documented on the form included in Appendix D. These forms will be kept on file on-site by the Fletcher/West Fork Underground Water Manager, Gary Henry or designee. In addition, all significant water management measures and best management practices implemented at Fletcher/West Fork Mine will be documented in writing and a copy kept on file at the same location. Actions taken, best management practices, inspections, and maintenance of underground water management measures will be recorded in the Doe Run ETMS.

4.7 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between February 1, 2013 and March 31, 2013. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Fletcher/West Fork Mine facility.

4.8 IMPLEMENTATION SCHEDULE

The current schedule for the water management plan implementation is presented in Table 4-2. This schedule is based on the best information available as of the date of this plan.

Table 4-2. Revised Implementation Schedule for Underground Water Management Plan Activities at Fletcher/West Fork Mine.

<table>
<tr><th>Action</th><th>April 2012</th><th>May 2012</th><th>June 2012</th><th>July 2012</th><th>Aug. 2012</th><th>Sept. 2012</th><th>Oct. 2012</th><th>Nov. 2012</th><th>Dec. 2012</th><th>Jan. 2013</th><th>Feb. 2013</th><th>March 2013</th><th>June 2013</th><th>Mar. 2014</th></tr>
<tr><td>Training</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Inspections</td><td colspan="14">Once per Calendar Quarter</td></tr>
<tr><td>Sampling</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="8">As Needed</td></tr>
<tr><td>Plug Old Powerline Hole</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plan Review & Update</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

5. REFERENCES

LimnoTech. Underground Water Sampling and Analysis Plan Report. August 4, 2011. (LimnoTech, 2011)

Resource Environmental Management Consultants, Inc. *Master Underground Water Management Plan: The Doe Run Company SEMO Operations*. 2010. (RMC, 2010)

U.S. Geological Survey. “History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict” (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008)

This page is blank to facilitate double sided printing.

APPENDIX A:

FLETCHER/WEST FORK MINE WATER FLOW MAP WITH LEAD AND ZINC SAMPLING RESULTS

This page is blank to facilitate double sided printing.

Fletcher Mine
Water Schematic
Scale 1" = 500'
August 25, 2011
LEGEND
203 Vent Shaft Ditch
TPb DPb TZn DZn TSS
2-8-11 63.3 41.8 28.0 32.0 45.0
20 GPM
FL-203 Open Stope EFF
TPb DPb TZn DZn TSS
2-8-11 78.7 71.4 1640 1550 0
3-23-11 388 62.7 1830 1730 6.0
6-8-11 85 41 1825 1573 0
150 GPM
FL-1040 Sump
Flygt Model 2151: 30HP HV
1,000 GPM capacity
1040 Sump INF
TPb DPb TZn DZn TSS
2-8-11 82.4 69.5 1580 1510 0
3-23-11 79.1 72.3 1770 1710 0
6-8-11 73 40 1972 1729 1
300 GPM
FL-SAT BT Sump
Flygt Model 2102: 8HP HV
600 GPM capacity
1040 Sump EFF
TPb DPb TZn DZn TSS
2-8-11 85.6 68.1 1610 1540 0
3-23-11 82.3 66.7 1740 1630 0
6-8-11 80 38 2014 1719 0
6-8Dup 76 39 2011 1743 0
FL-NW Satellite Sump Influent
TPb DPb TZn DZn TSS
2-8-11 19200 50.9 10200 1410 414
500 GPM
FL-NW Satellite Sump Effluent
TPb DPb TZn DZn TSS
2-8-11 1120 51.0 1390 1200 17.0
3-23-11 163 52.6 1480 1390 0
6-8-11 95 40 1852 1606 0
800 GPM
FL-201 PL Sump
Flygt Model 2201: 58HP HV
2,250 GPM capacity
FL-North WF Sump Influent
TPb DPb TZn DZn TSS
2-8-11 136 74.9 1860 1830 0
3-23-11 98.2 79.2 1510 1440 0
6-8-11 77 34 1791 1512 3
800 GPM est. ave.
FL-WF Sump (to surface)
Gould: 350HP x 2
1,000 GPM capacity per pump
Gould Model VIT-FF 6X13ALC: 200HP
500 GPM capacity
1,400 GPM est. ave.
FL-South WF Sump Influent
TPb DPb TZn DZn TSS
2-8-11 138 50.0 1080 1050 0
3-23-11 340 53.4 1120 1030 16.0
6-8-11 129 31 1117 955 6
600 GPM est. ave.
Water goes to West Fork Sump ↑
Water goes to Fletcher Sumps ↓
FL-North Bypass #1 Ditch
TPb DPb TZn DZn TSS
2-8-11 376 51.8 1540 1510 20.0
3-23-11 148 53.6 1410 1340 11.0
6-8-11 794 33 2207 1935 13
25 GPM est. ave.
FL-C10 Bypass Ditch
TPb DPb TZn DZn TSS
2-8-11 186 61.0 153 132 47.0
3-23-11 536 63.0 158 139 18.0
6-8-11 287 30 110 77 7
15 GPM est. ave.
FL-North Bypass #2 Ditch
TPb DPb TZn DZn TSS
2-8-11 368 57.2 128 98.6 0
3-23-11 8840 68.6 874 142 34.0
40 GPM est. ave.
FL-North Bypass Sump Effluent
TPb DPb TZn DZn TSS
2-8-11 1160 59.7 358 221 30.0
3-23-11 5230 70.2 455 176 80.0
6-8-11 26720 55 1943 40 942
300 GPM
FL-16BT/10Vent
150 GPM est. ave.
FL-19 btm Sump
1,000 GPM capacity
FL-#8 Sump Influent
TPb DPb TZn DZn TSS
2-8-11 5400 67.8 377 40.4 146
3-23-11 17200 77.4 1170 42.5 438
FL-19 btm Sump
Flygt Model 2125: 13HP HV
300 GPM capacity
FL-North Pump Sump Influent
TPb DPb TZn DZn TSS
6-8-11 2267 46 241 140 38
1,400 GPM est. ave.
FL-#8 Sump (to surface)
Peerless Model 14LC: 500HP x 2
1,200 GPM capacity per pump
FL-North Main Sump (to surface)
Peerless Model 14LC: 500HP x 2
1,200 GPM capacity per pump
FL-#8 Pump Sump
TPb DPb TZn DZn TSS
2-8-11 0.29 0.13 0 0 0
3-23-11 1850 70.8 295 194 27.0
1200 GPM est. ave.
FL-South Main Sump (to surface)
Peerless Model 14LC: 500HP x 3
1,000 GPM capacity per pump
FL-Skip Pocket
TPb DPb TZn DZn TSS
2-14-11 25800 74.9 3600 192 1080
6-8-11 24430 62 946 47 431
FL-South Pump Sump Influent
TPb DPb TZn DZn TSS
2-8-11 6050 63.8 429 54.1 173
3-23-11 7900 77.7 377 34.6 236
6-8-11 4958 60 288 63 163
3,000 GPM est. ave.
FL-Skip Pocket (aka "swimming pool")
Flygt Model 2125: 13HP HH
300 GPM capacity
100 GPM est. ave. (disch. into N. sump)
FL-RCWF East Effluent
TPb DPb TZn DZn TSS
3-23-11 8800 65.8 294 32.9 192
6-8-11 312 55 32 26 8
1,600 GPM est. ave.
FL-Shaft Bottom Pumps
Flygt Model 2102: 8HP HH x 2
600 GPM capacity per pump
FL-RCWF West Effluent
TPb DPb TZn DZn TSS
2-8-11 5040 56.0 326 23.4 137
3-23-11 400 47.1 15.6 6.1 5.0
3-23Dup 510 46.6 12.8 15.8 6.0
6-8-11 1070 53 27 8.5 46
2,200 GPM est. ave.
FL-Old Powerline Hole
TPb DPb TZn DZn TSS
2-14-11 25.5 21.1 0 16.2 0
3-23-11 52.3 24.4 38.8 44.7 0
3-23Dup36.2 23.4 43.4 48.8 0
6-8-11 20 11 5.6 9.2 1
10 GPM est. ave.
FL-South Ditch
400 GPM
FL-7 Sump North Ditch
Flygt Model 2201: 58HP HV x 2
2,250 GPM capacity per pump
FL-7 Sump North Ditch
TPb DPb TZn DZn TSS
2-8-11 3080 50.2 270 111 110
100 GPM
13 u/c Sump
Flygt Model 2125: 13HP
300 GPM capacity
FL-7 Sump South Ditch
TPb DPb TZn DZn TSS
2-8-11 238 52.2 66.6 75.4 8.0
3-23-11 650 67.1 157 117 19.0
6-8-11 24520 56 1496 59 774
13 Vent Shaft INF
TPb DPb TZn DZn TSS
2-14-11 320 32.5 14.7 8.2 48.0
13 Vent Shaft Ditch
TPb DPb TZn DZn TSS
2-14-11 143 59.6 248 225 0
3-23-11 262 61.7 267 226 10
6-8-11 2397 50 172 54 66
15 Vent Shaft Ditch
TPb DPb TZn DZn TSS
2-14-11 277 30.5 30.7 16.2 15.0
3-23-11 322 39.7 60.1 47.2 8.0
6-8-11 3914 44 114 22 83
15 Vent Shaft Sump
Flygt Model 2201: 58HP HH
1,000 GPM capacity
15 Vent Shaft Influent
TPb DPb TZn DZn TSS
2-14-11 1.3 0.6 0 0 12.0
3-23-11 0 0.96 0 7.2 0
6-8-11 622 28 20 7.8 14
6-8Dup 362 23 14 6.4 20
900 GPM est. ave. flow
86 Sump
Flygt Model 2201: 58HP HH
1,000 GPM capacity
84 Sump
Flygt Model 2151: 30HP
1,400 GPM capacity
FL-86 Sump Ditch Influent
TPb DPb TZn DZn TSS
2-14-11 1190 53.4 140 106 29.0
3-23-11 34900 60.2 1450 124 1150
6-8-11 377 34 85 61 9
100 GPM est. ave. flow
FL-84 Sump Ditch Influent
TPb DPb TZn DZn TSS
2-14-11 27600 59.3 1360 86.0 727
3-23-11 13100 51.9 585 97.5 355
6-8-11 753 36 137 92 17
100 GPM est. ave. flow
FL-29 Sump Ditch Effluent
TPb DPb TZn DZn TSS
2-14-11 122 52.8 56.9 51.6 8.0
3-23-11 140 55.2 53.8 49.9 0
6-8-11 312 33 54 33 5
50 GPM est. ave. flow
29 Sump
Flygt Model 2125: 13HP
300 GPM capacity
FL-RCWF Lunchroom Sump
Flygt Model 2125: 13HP
300 GPM capacity
FL-29 Sump Ditch Influent
TPb DPb TZn DZn TSS
2-14-11 302 58.9 104 102 52.0
3-23-11 606 48.9 72.7 62.9 8.0
6-8-11 3204 37 115 39 147
30 GPM est. ave. flow
RCWF Main Sump
Process Systems Model 12Y-1100: 125HP x 2
1,000 GPM capacity each
Process Systems Model 5EMM-1850: 250HP
2,000 GPM capacity
2,800 GPM est. ave. flow
FL-RCWF Sump Ditch INF
TPb DPb TZn DZn TSS
2-14-11 7300 77.1 550 17.5 258
3-23-11 9640 68.2 290 19.4 352
6-8-11 475 37 21 14 17
FL-RCWF DVN Ditch
TPb DPb TZn DZn TSS
2-14-11 236 61.1 27.0 24.0 5.0
3-23-11 12900 65.4 196 34.5 346
6-8-11 257 30 22 20 0
800 GPM est. ave. flow
FL-RCWF South #1 Sump Pump
TPb DPb TZn DZn TSS
2-14-11 1170 63.0 63.6 14.1 49.0
3-23-11 621 60.5 43.5 17.6 20.0
FL-RCWF South #1 Sump
Flygt Model 2151: 30HP HV x 3
1,000 GPM capacity each
Flygt Model 2201: 58HP HV
2,000 GPM capacity
2,000 GPM ave. flow (metered)
FL-RCWF South #1 Sump Ditch
TPb DPb TZn DZn TSS
2-14-11 12100 74.6 1160 11.8 170
3-23-11 13700 63.6 784 20.2 353

APPENDIX B:

VENDOR INFORMATION ON GROUT USED FOR COREHOLE SEALING

This page is blank to facilitate double sided printing.

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

HYPERFLEX

Single component, low density, flexible, hydrophobic grout.

Uses

Sealing of water and gasses in mining and civil applications. Reacts with moisture to form a flexible closed cell grout.

Advantages

- **Simple application**
- **Adjustable set time with catalyst**
- **Flexible, absorbs movement**
- **Low expansive pressure**
- **"Self injection" into the finest of fractures**

Packaging

55 Gallon Steel Drums
5 Gallon Plastic Containers
5 Gallon Metal Containers
1 Gallon Metal Containers

Approvals

NSF 61-2007 approved for use with potable water.

Transport

USDOT. Unregulated Class 55

Physical Properties

Density	Free rise	2.25 lbs/ft³
Low temp. aging	Confirmed	
-20° F (shrinkage)	0% 1 Day	ASTM D-2126
Viscosity	4000 cps	ASTM D-2126
Specific Gravity @ 60° F	1-30%	A-Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Compressive	25 psi	ASTM D-1621
Shear	171 psi	ASTM C-273
Tensile	30 psi	ASTM D-1623
Elongation	300%	ASTM D-1623

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture.

Shelf Life

2 year minimum in unopened containers.

Caution: Always read MSDS prior to use.

WWW.Sub-Technichal.com

724 625 0008 VOICE 724 625 0009 Fax

Sub-Technical Inc.

CHEMICAL GROUTING SPECIALISTS

STI 03 - 0.03

H20STOP

Dual component, low density, highly reactive, early strength, water control grout

Uses

Water control in mining and civil applications for cessations of high (3,000 G.P.M. +) leaks, combined with rapid void filling and early strength characteristics.

Advantages

- **Extremely fast reacting**
- **Rapid sealing**
- **High early strength**
- **Will inject into the finest of fractures**
- **Will not wash out**

Storage

Store in airtight containers. Product should not be exposed to the atmosphere until application. Product is moisture sensitive. Avoid contact with moisture. Store under 80 degrees.

Packaging

55 Gallon Steel Drums

Approvals – On file

Transport

USDOT Unregulated Class 55

Shelf Life

2 Year minimum in unopened containers.

Physical Properties

-20º F (shrinkage)	0% 1 day	ASTM D-2126
Viscosity @ 68º F	200 cps A – Side	300 cps B – Side
Specific Gravity @ 60º F	1.23 A - Side	1.04 B - Side
% Solids	100%	
Color	Amber	
Solvents	None	

Test Data

Density (Free Rise)	03 PCF	ASTM D-1622
Compressive	200 psi	ASTM D-1621
Tensile	112 psi	ASTM D-638
Shear	107 psi	ASTM D-732

Sub-Technical, Inc.
363 Mars Valencia Road
Mars, Pennsylvania 16046 U.S.A.
Phone: (724)625-0008 Fax: (724)625-0009
www.sub-technical.com
stisales@sub-technical.com

Always Read MSDS Sheets Prior to USE

APPENDIX C:

STANDARD OPERATING PROCEDURES

This page is blank to facilitate double sided printing.

I. INTRODUCTION

Exploration coreholes at the Doe Run Mines are currently sealed by mine personnel. This practice has been in place for many years. New coreholes that are encountered during mining operations and that produce significant flows to the mine will be sealed, if sealing is technically feasible. This standard operating procedure provides a decision framework and guidelines for monitoring and sealing coreholes when they are encountered during mining operations.

II. MATERIALS

The following materials, as required, will be used when coreholes are encountered:

- Any necessary safety equipment;
- 55 gallon drum or other similarly sized container of known volume;
- 5 gallon bucket or similar smaller container;
- Stopwatch;
- Measuring tape;
- Field log;
- Mine map;
- Camera.

III. PROCEDURES / GUIDELINES

When a corehole is encountered during mining operations the following procedures shall be used:

A. Determine flow rate from corehole

1) Flowrate from the corehole will be estimated by measuring the time required to fill a 55 gallon drum or other similarly sized container of known volume.
2) If the location of the corehole prevents the use of a 55 gallon drum or if the flow is too small for filling of a 55-gallon drum to be practical, then a 5 gallon bucket or similar smaller container will be used.
3) If, due to the quantity of flow or for safety reasons, it is not possible to measure the flow, this should be reported to the underground water management team who will determine an alternate flow estimation method.
4) Because flows often change after coreholes are encountered, the flow rate will be measured once per month for three months to obtain a better estimate of its long-term flow.

B. Measure the corehole diameter

1) The diameter of the corehole will be measured to the nearest inch.
2) If it is infeasible to measure the diameter due to the position of the corehole or for safety reasons, the diameter will be visually estimated.

C. Determine if sealing is required and feasible

1) If the flow from the corehole exceeds 25 gallons per minute the corehole will be sealed.
2) The underground water management team will evaluate whether the corehole can be sealed using the methods and materials that have been used at the mine in the past.
3) If it is unclear whether sealing is feasible, the underground water management team will consult with manufacturer's representatives for mechanical plugs and grouts to help

determine the feasibility of sealing the corehole.

D. Seal the corehole

If it has been determined that the corehole can be sealed, the underground water management team will determine a schedule for the sealing work and ensure that the work is completed.

E. Documentation

The following information must be recorded in writing and submitted to the underground water manager:

1) Corehole discovery time and date.
2) Location of corehole recorded on map
3) Diameter of corehole
4) Measured flowrate – record procedure and results
5) Determination of sealing requirement
6) Problems encountered with sealing determination
7) Communication with the underground water management team
8) If the corehole cannot be sealed – record the reasons for that determination
9) Methods and procedures of corehole sealing
10) Problems encountered in the sealing process and apparent success
11) Sealing completion time and date.
12) Pictures of the corehole will also be taken and kept with the field log.

I. INTRODUCTION

Mine water sumps provide temporary storage for mine water, which results in the settling of solids proportional to the hydraulic residence time. Central mine water sumps are the largest sumps and allow the greatest settling of solids. This means that the accumulating solids will fill the sump over time and reduce the hydraulic residence time. If not maintained, the accumulated solids could eventually impede pumping. For these reasons, periodic maintenance of the sumps is required to remove accumulated solids.

The process of sump cleaning is referred to as “sump mucking”. This involves draining the sump, then mechanically removing the accumulated solids from the sump. This standard operating procedure provides guidelines for monitoring main mine water sumps and determining the need for sump cleanout.

II. MATERIALS

The following materials will be available to monitor mine sumps:

- Personal protective equipment as required by the Health and Safety Plan;
- Light source;
- Depth finding device;
- Tape measure;
- Field log;

III. PROCEDURES / GUIDELINES

All major mine sumps will be cleaned when the accumulated solids exceed 50% of the water depth in the sump at the point of measurement near the pumps. To determine the sump mucking trigger, the following procedures must be adhered to:

A. Depth Measurement

1) A depth finding sonar device will be installed near the pumps at each of the major mine sumps to measure the depth of sediment in the sump.
2) A standard reference mark will be established for each sump, to which the water level can be referenced on a recurring basis.
3) The water level will be determined by measuring from the standard reference mark down to the water level with a tape measure.
4) As an alternative to steps 2 and 3, mine personnel may opt to install a staff gauge in the sump for measuring water level.

B. Inspection

1) During each quarterly inspection, the water level and depth to solids in each sump will be recorded from depth finding device.

C. Documentation

The following information will be recorded:

1) Sump identification/location
2) Sump inspection date
3) Measurement of water level
4) Measurement of depth to sediment in each sump
5) Notification of underground water management team, if the depth of solids is more than 50% of the water depth in the sump
6) Start and end date for sump cleanout and problems encountered

APPENDIX D:

UNDERGROUND WATER CONTROL MEASURE INSPECTION FORM

This page is blank to facilitate double sided printing.

Underground Water Management Inspection

Date: ________________________ **Inspection By:**_________________________

Mine: ____

Notes: ____

Sumps

Sump ID/Location	Water Level	Depth to Sediment	Notification Date

Notes: ____

____

____

Piping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

Underground Water Management Inspection

Date: ______________________ **Inspection By:**_______________________

Roadways

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

BMPs/General Housekeeping

Location	Describe Condition/Maintenance Needed/Actions Taken (use additional sheets if needed)

EXHIBIT O

EXHIBIT O

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 47
Site-Specific Surface Water Management Plan ("SWMP") Implementation Status Report
Viburnum Mine #35 ("Casteel")

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific SWMP for Casteel on April 30, 2012. Doe Run received approval notification from EPA on June 14, 2012. This Status Report provides a summary of the actions conducted pursuant to the Casteel SWMP since approval.

Training. Initial training, including education of key mine personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. Further detailed training for key mine and environmental personnel was completed on August 9, 2012, August 10, 2012, and August 13, 2012. In addition, the Environmental Technician for Casteel received additional training on August 9, 2012 as to the SWMP to assist with ongoing on-site training and questions regarding SWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise.

Sampling. The SWMP suggests sampling at locations specified in the plan twice monthly for the first plan year. Doe Run has conducted surface sampling at Casteel twice monthly at all but one location specified in the plan from June to September 2012. The remaining location was sampled twice in September 2012. After the first six months, if the distribution of the data indicates that twice monthly sampling is unlikely to provide a more thorough understanding of water quality at these locations, the monitoring frequency at some or all of the locations may be reduced to monthly or quarterly.

Pilot Tests. The SWMP discusses the completion of two pilot studies with the expected completion date of October 1, 2012. Two pilot projects were conducted at Doe Run's Buick Mine/Mill facility and Brushy Creek Mine/Mill facility. One project included metals precipitation through the addition of chemicals and the other included metals precipitation through the addition of chemicals as well as ion exchange. The pilot projects were complete in July 2012. The SWMP indicates that upon completion of the mine water treatment pilot studies, Doe Run will evaluate the cost-effectiveness of a mine water treatment for Casteel. This is currently underway.

Stormwater Collection Basin. The SWMP indicates the construction permit application for the stormwater collection basin will be submitted by August 1, 2012. The application was submitted to MDNR on July 31, 2012.

Mine Water Transfer. The SWMP indicates that Doe Run will submit a request for MDNR to provide feedback on the concept of transferring mine water from Casteel Mine to the new Viburnum tailings basin by June 30, 2012. Doe Run sent the request to MDNR on May 7, 2012. The SWMP indicates that the regulatory review will be completed by August 31, 2012. Doe Run received approval to pilot test the pumping of mine water from Casteel to Viburnum on July 12, 2012. The SWMP indicates that the evaluation of technical feasibility of the mine water transfer would be complete by September 1, 2012. This evaluation was completed on August 17, 2012. The SWMP indicates that the technical feasibility and cost of water transfer will be complete by October 31, 2012. The technical feasibility, as previously stated, is complete and the cost of water transfer is currently being evaluated and will be completed by October 31, 2012. The SWMP indicates that Doe Run will evaluate the feasibility and cost-effectiveness of Casteel mine water treatment versus transferring the mine water to Viburnum by December 31, 2012. This evaluation is currently underway and will be complete by December 31, 2012.

Inspections. Best management practices are inspected at Casteel every month pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). SWPPP Inspections were conducted on June 27, 2012, July 30, 2012, August 30, 2012, and September 27, 2012. These inspection records are kept on-site at Casteel.

Recordkeeping. Doe Run has incorporated tasks described in the Casteel SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site.

Plan Review and Update. The SWMP is scheduled to be reviewed and revised between February 1, 2013 and April 30, 2013. Doe Run will review and revise the SWMP at that time. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT P

EXHIBIT P

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 47
Site-Specific Surface Water Management Plan ("SWMP") Implementation Status Report
Brushy Creek Mine/Mill ("Brushy Creek")

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific SWMP for Brushy Creek on May 30, 2012. Doe Run received approval notification from EPA on July 15, 2012. This Status Report provides a summary of the actions conducted pursuant to the Brushy Creek SWMP since approval.

Training. Initial training, including education of key mine personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. Further detailed training for key mine and environmental personnel was completed on August 9, 2012, and August 13, 2012. In addition, the Environmental Technician for Brushy Creek received additional training on August 9, 2012 as to the SWMP to assist with ongoing on-site training and questions regarding SWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise.

Sampling. The SWMP suggests sampling at locations specified in the plan as often as twice monthly for the first plan year. Doe Run has conducted surface sampling at Brushy Creek twice monthly at all locations specified in the plan from July to September 2012. After the first six months, if the distribution of the data indicates that twice monthly sampling is unlikely to provide a more thorough understanding of water quality at these locations, the monitoring may cease or monitoring frequency at some or all of the locations may be reduced to monthly or quarterly.

Pilot Studies. The SWMP discusses the completion of two pilot studies with the expected completion date of October 1, 2012. Two pilot projects were conducted at Doe Run's Buick Mine/Mill facility and Brushy Creek Mine/Mill facility. One project included metals precipitation through the addition of chemicals and the other included metals precipitation through the addition of chemicals as well as ion exchange. These two pilot projects were completed in July 2012. The SWMP indicates that upon completion of the mine water treatment pilot studies, Doe Run will evaluate the cost-effectiveness of a mine water treatment for Brushy Creek. This is currently underway. The SWMP also discusses the completion of the pilot test involving pumping of mine water directly into the tailings impoundment at Brushy Creek, prior to pumping it o the mine water basin. A summary report of this pilot test was to be submitted to MDNR by August 1, 2012. Doe Run requested and was granted an extension on this report with a new scheduled due date of August 9, 2012. Doe Run submitted the summary of the pilot project on August 9, 2012.

Inspections. Best management practices are inspected at Brushy Creek every month pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). SWPPP Inspections were conducted on July 18, 2012, August 10, 2012, and September 14, 2012. These inspection records are kept on-site at Brushy Creek.

Recordkeeping. Doe Run has incorporated tasks described in the Brushy Creek SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site.

Plan Review and Update. The SWMP is scheduled to be reviewed and revised between April 1, 2013 and May 31, 2013. Doe Run will review and revise the SWMP at that time. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT Q

EXHIBIT Q

The Doe Run Resources Corporation (“Doe Run”)
Multi-Media Consent Decree (“Consent Decree”)
Paragraph 47
Site-Specific Surface Water Management Plan (“SWMP”) Implementation Status Report
Buick Mine/Mill (“Buick”)

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific SWMP for Buick on June 29, 2012. Doe Run received approval notification from EPA on August 9, 2012. This Status Report provides a summary of the actions conducted pursuant to the Buick SWMP since approval.

Training. Initial training, including education of key mine personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. Further detailed training for key mine and environmental personnel was completed on August 22, 2012, August 27, 2012, and September 6, 2012. In addition, the Environmental Technician for Buick received additional training on August 16, 2012 as to the SWMP to assist with ongoing on-site training and questions regarding SWMP implementation. The Environmental Technicians are available to conduct ongoing training for mine personnel to address issues or questions that arise.

Sampling. The SWMP suggests sampling at locations specified in the plan as often as monthly for the first plan year. Doe Run has conducted surface sampling at Buick twice monthly at all locations specified in the plan from August to September 2012. After the first six months, if the distribution of the data indicates that monthly sampling is unlikely to provide a more thorough understanding of water quality at these locations, the monitoring may cease or monitoring frequency at some or all of the locations may be reduced to monthly or quarterly.

Pilot Studies. The SWMP discusses the completion of two pilot studies to support determination of the most effective and economical way to meet future final Missouri State Operating Permit limits. Two pilot projects were conducted at Doe Run’s Buick Mine/Mill facility and Brushy Creek Mine/Mill facility. One project included metals precipitation through the addition of chemicals and the other included metals precipitation through the addition of chemicals as well as ion exchange. These two pilot projects were complete in July 2012. The SWMP indicates that upon completion of the mine water treatment pilot studies, Doe Run will evaluate the cost-effectiveness of a mine water treatment for Buick. This is currently underway.

Inspections. Best management practices are inspected at Buick every month pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). SWPPP Inspections were conducted on August 31, 2012, and September 18, 2012. These inspection records are kept on-site at Buick.

Recordkeeping. Doe Run has incorporated tasks described in the Buick SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site.

Plan Review and Update. The SWMP is scheduled to be reviewed and revised between April 1, 2013 and May 31, 2013. Doe Run will review and revise the SWMP at that time. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT R

EXHIBIT R

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 47
Site-Specific Surface Water Management Plan ("SWMP") Implementation Status Report
Fletcher Mine/Mill ("Fletcher")

Paragraph 46.b of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific SWMP for Fletcher on July 30, 2012. Doe Run did not receive a response from MDNR or EPA within 45 days of submittal. Pursuant to Paragraph 46.a of the Consent Decree, the SWMP was deemed approved on September 13, 2012. This Status Report provides a summary of the actions conducted pursuant to the Fletcher SWMP since approval.

Training. Initial training, including education of key mine personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. The SWMP indicates that further detailed training for personnel directly involved in the management of water at Fletcher will be conducted in conjunction with the SWPPP training. Annual refresher training for the SWPPP at Fletcher is scheduled to be completed in October 2012 and initial training for the SWMP will be conducted at that time.

Sampling. The SWMP indicates that water quality monitoring will continue at Fletcher facility as required by the Missouri State Operating Permit ("MSOP") and sampling at other locations will be assessed and implemented on an as-needed basis. Sampling according to the MSOP, as well as other monitoring locations, was completed on September 5, 2012 and September 18, 2012.

Pilot Studies. The SWMP discusses the completion of two pilot studies to support determination of the most effective and economical way to meet future final Missouri State Operating Permit limits. Two pilot projects were conducted at Doe Run's Buick Mine/Mill facility and Brushy Creek Mine/Mill facility. One project included metals precipitation through the addition of chemicals and the other included metals precipitation through the addition of chemicals as well as ion exchange. These two pilot projects were complete in July 2012. The SWMP indicates that upon completion of the mine water treatment pilot studies, Doe Run will evaluate the cost-effectiveness of a mine water treatment for Fletcher. This is currently underway.

Inspections. Best management practices are inspected at Fletcher every month pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). A SWPPP inspection was conducted on September 28, 2012. These inspection records are kept on-site at Fletcher.

Recordkeeping. Doe Run has incorporated tasks described in the Fletcher SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site.

Plan Review and Update. The SWMP is scheduled to be reviewed and revised between June and July, 2013. Doe Run will review and revise the SWMP at that time. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT S

EXHIBIT S

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 47
Site-Specific Surface Water Management Plan ("SWMP") Implementation Status Report
West Fork Mine/Mill ("West Fork")

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific SWMP for West Fork on August 27, 2012. Doe Run received approval notification from EPA on September 27, 2012. This Status Report provides a summary of the actions conducted pursuant to the West Fork SWMP since approval.

Training. Initial training, including education of key mine personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. The SWMP indicates that further detailed training for personnel directly involved in the management of water at West Fork will be conducted in conjunction with the SWPPP training. Annual refresher training for the SWPPP at West Fork is scheduled to be completed in October 2012 and initial training for the SWMP will be conducted at that time.

Sampling. The SWMP indicates that water quality monitoring will continue at West Fork facility as required by the Missouri State Operating Permit ("MSOP") and sampling at other locations will be assessed and implemented on an as-needed basis. Sampling according to the MSOP, as well as other monitoring locations, was completed on September 5, 2012 and September 18, 2012.

Pilot Studies. The SWMP discusses the completion of two pilot studies to support determination of the most effective and economical way to meet future final Missouri State Operating Permit limits. Two pilot projects were conducted at Doe Run's Buick Mine/Mill facility and Brushy Creek Mine/Mill facility. One project included metals precipitation through the addition of chemicals and the other included metals precipitation through the addition of chemicals as well as ion exchange. These two pilot projects were complete in July 2012. The SWMP discusses the pilot test involving discharge of mine water directly to the tailings impoundment at West Fork. This pilot study is currently underway. The SWMP also indicates that upon completion of the mine water treatment pilot studies, Doe Run will evaluate the cost-effectiveness of a mine water treatment for West Fork. This is currently underway.

Inspections. Best management practices are inspected at West Fork every month pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). A SWPPP inspection was conducted on September 28, 2012. These inspection records are kept on-site at West Fork.

Recordkeeping. Doe Run has incorporated tasks described in the West Fork SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site.

Plan Review and Update. The SWMP is scheduled to be reviewed and revised between June and July, 2013. Doe Run will review and revise the SWMP at that time. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT T

EXHIBIT T

The Doe Run Resources Corporation (“Doe Run”)
Multi-Media Consent Decree (“Consent Decree”)
Paragraph 47
Site-Specific Surface Water Management Plan (“SWMP”) Implementation Status Report
Herculaneum Lead Smelter Facility (“Herky”)

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted the Site-Specific SWMP for Herky on January 10, 2012. On February 24, 2012, Doe Run received a partial disapproval part notification from the EPA. Doe Run on February 24, 2012, Doe Run submitted a revised Site-Specific SWMP for the Herculaneum Lead Smelter Facility on March 26, 2012. Doe Run resubmitted the SSSWMP on March 30, 2012. This Status Report provides a summary of the actions conducted pursuant to the Herky SWMP.

Training. Initial training, including education of key smelter personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. Further detailed training for key smelter and environmental personnel was completed during the Environmental Annual Refresher Trainings on March 6-10, 2012. The environmental department facilitators are available to conduct ongoing training for smelter personnel as needed.

Sampling. The SWMP states that Doe Run will take weekly WWTP influent monitoring (Forebay) samples, weekly monitoring samples at NPDES locations, quarterly groundwater monitoring samples at the SSA, and special project monitoring for source reduction efforts. Doe Run has completed all required sampling except for the special project monitoring as we are meeting final limits and no special projects were needed.

Cadmium Reduction Project. The cadmium project consists of packaging and selling of cadmium products located primarily in the dust from the ESP and baghouse. Doe Run has seen a decrease in Cadmium loading to the WWTP due to this project. Forebay influent samples that were collected weekly for operational purposes were used to track this long term trend. Since the project was initiated in December of 2010, only one month (November 2011) was above final limits.

Water Characterization Study/Process Determination: Doe Run is meeting final limits with the current design; therefore, no process changes will be implemented.

Stormwater Capture. The SWMP predicted that Herky has sufficient capacity to store, contain and treat a 2.8-inch storm event. On August 31, 2012 Herky experienced a 2.25 inch rainfall with no storage, containment or treatment issues.

Inspections. Inspections were conducted pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). These inspection records are kept on-site at Herky.

Recordkeeping. Doe Run has incorporated tasks described in the Herky SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site and in the Doe Run LMS system.

Plan Review and Update. The SWMP is scheduled to be reviewed and revised between October 2012 and April 2014. Doe Run will review and revise the SWMP as needed. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT U

EXHIBIT U

The Doe Run Resources Corporation (“Doe Run”)
Multi-Media Consent Decree (“Consent Decree”)
Paragraph 47
Site-Specific Surface Water Management Plan (“SWMP”) Implementation Status Report
Glover Facility (“Glover”)

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted the Site-Specific SWMP for Glover March 1, 2012. Doe Run received approval from the EPA on April 16, 2012. This Status Report provides a summary of the actions conducted pursuant to the Glover SWMP.

Training. Initial training, including education of key personnel, as to the various elements of the SWMP, was initiated during the development of the SWMP. The environmental department facilitators are available to conduct ongoing training for smelter personnel as needed.

Sampling. The SWMP states that Doe Run will take WWTP influent monitoring as needed during operations, Monthly monitoring at MSOP locations, and special project monitoring for source reduction efforts. Doe Run has completed all required sampling except for the special project monitoring as Glover is meeting final limits and no special projects were needed.

Inspections. Inspections were conducted pursuant to the site-specific Stormwater Pollution Prevention Plan (SWPPP). These inspection records are kept on-site at Glover.

Recordkeeping. Doe Run has incorporated tasks described in the Glover SWMP implementation schedule into its Enterprise Task Management System ("ETMS"). The ETMS provides notification to assigned Doe Run personnel of upcoming implementation schedule deadlines. Doe Run keeps records discussed in the SWMP on-site and in the Doe Run LMS system.

Asarco/Doe Run Slag Storage Area Closures. The ASARCO storage area closure is on hold pending MDNR funding. The closure activities will begin after the funding is completed.

Plan Review and Update. The SWMP is scheduled to be reviewed and as needed. Progress reports will be provided as required by Paragraph 47 of the Consent Decree.

EXHIBIT V

EXHIBIT V

The Doe Run Resources Corporation ("Doe Run")
Multi-Media Consent Decree ("Consent Decree")
Paragraph 47
Site-Specific Surface Water Management Plan ("SWMP") Implementation Status Report
Buick Resource Recycling Facility ("BRRD")

Paragraph 46 of the Consent Decree required Doe Run to develop a Site-Specific Surface Water Management Plan and submit it to EPA for review. Paragraph 47 of the Consent Decree requires Doe Run to provide a summary of the progress of implementation as part of the Semi-Annual Status Report. Paragraph 48 of the Consent Decree requires Doe Run to note any modifications to its Site-Specific SWMP in the Semi-Annual Status Report.

Doe Run submitted its Site-Specific SWMP for BRRD on April 2, 2012. Doe Run received comments and a partial disapproval from EPA and MDNR on June 14, 2012. Doe Run submitted a revised Site-Specific SWMP for the Buick Resource Recycling Facility on July 16, 2012. This Status Report provides a summary of the actions conducted at BRRD.

CONSTRUCTION OF WWTP UPGRADES. On June 10, 2012 BRRD received the construction permit for the new wastewater treatment plant to be built. Construction has been progressing in earnest. Planned shakedown and startup of the new waste water treatment plant is currently planned for mid-November, 2012.

CONSTRUCTION OF ENCLOSED MATERIAL STORAGE BUILDING. Construction of the Enclosed Material Storage Building has begun; with the walls and floor have been poured. A permit modification for use of the building was submitted to the Missouri Department of Natural Resources Hazardous Waste Program on May 1, 2012. The facility is awaiting comments on the submitted Class 2 permit modification.

REDIRECT LANDFILL LEACHATE FOR REUSE IN PROCESS. A Class 1 permit modification was submitted to the Missouri Department of Natural Resources Hazardous Waste Program on May 3, 2012. A phone conference with Department was on August 20, 2012 at which time several questions were raised. Our understanding at that time was to present potential projects to address those questions. A letter was submitted outlining potential projects to be used in filing an amended Class 1 permit modification on October 16, 2012. The facility is awaiting comments on potential projects presented.

NEW REVERBERATORY DRY SCRUBBER AND BAGHOUSE. BRRD is still operating the new reverberatory dry scrubber and baghouse which went on line on April 3, 2012.

CHANGE FROM SODIUM CARBONATE TO CALCIUM CARBONATE. Sodium carbonate is no longer being used to remove sulfur from the battery paste at the BDC building.

MONITORING, PERFORMANCE ASSESSMENT, & ADAPTIVE MANAGEMENT. SWPPP and SPCC implementation have been completed. Inspections are continuing as scheduled and records of the inspections are being maintained. At this time there are no modifications to the SWMP. The SWMP will be reviewed as scheduled in March 2013. A refresher training course for personnel will be completed in July 2013 or earlier.

MISCELLANOUS. Also, during the above time frame different and more robust reverberatory fluid air cooling pumps were installed. An additional pump has been added over what is required to allow maintenance of the primary pumps without interrupting the normal flow of water. The new pumps are believed to last longer, and their design will allow faster replacement should the need arise.

EXHIBIT W

SURFACE WATER MANAGEMENT PLAN for the CASTEEL MINE

(MSOP No. MO-0100226)

Prepared for: The Doe Run Resources Corporation
d/b/a The Doe Run Company

April 30, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

This page is blank to facilitate double sided printing.

1. INTRODUCTION

This document presents the Surface Water Management Plan (SWMP) for the Casteel Mine (Viburnum No. 35), prepared on behalf of The Doe Run Resources Corporation, d/b/a The Doe Run Company (Doe Run). The Casteel SWMP has been prepared in accordance with the Master SWMP previously prepared by LimnoTech (LimnoTech, 2011). In keeping with the Master SWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to attain future final effluent limits for discharges to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Casteel Mine is located in Iron County, Missouri, approximately 4 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Casteel Mine (USGS, 2008).

Year	Event
1978	Structures including the head frame and a building containing offices, a change room, and the hoist room were moved from the Viburnum No. 27 mine to Casteel.
1981	Started sinking mine shaft at Casteel
1983	Opened for production by the St. Joseph Lead Company. About 80% of ore was trucked to the Central Viburnum (Viburnum 28) Mill and 20% to the Brushy Creek Mill.
1992	Viburnum Mill closed, ore shipped to Buick Mill
1995	Viburnum Mill reopened
2001	Viburnum Mill closed, ore shipped to Buick Mill
2003	Casteel Mine ceased operation
2004	Casteel Mine resumed operation

Primary surface operations at the Casteel facility involve the transfer of lead, zinc and copper ore from the Casteel Mine to trucks which transport the ore to mills at other Doe Run facilities for processing. An aerial layout map of the Casteel facility is depicted in Figure 1-2. This figure shows several features relevant to this SWMP, including the following:

- Main building – The main building at Casteel has offices, employee locker and change rooms, workshop and hoist operations.
- Outfalls 001 and 003 – Outfalls 001 (sample ID = Casteel001) and 003 (sample ID = Casteel003) are the permitted points of discharge for mine water

from the Casteel facility. Flows at these outfalls are discussed in detail in Section 2.1.1 of this plan.

- Mine water box – Mine water is pumped from the Casteel Mine to the surface at the mine water box, where it is diverted to mine water basins 001 and 003. Mine water flows are discussed in more detail in Section 2.1.2 of this plan.
- Inflow from V10 sump – A new mine water sump, called V10 sump, was recently constructed in the Casteel Mine. The V10 sump pumps mine water to the surface at a different location from the mine water box and the mine water is then conveyed to mine water basin 003 via piping. The V10 sump is discussed further in Section 2.1.2 of this plan.
- Mine water basins 001 & 003 – Mine water diverted from the mine water box flows to either mine water basin 001 or mine water basin 003. These basins also receive storm water runoff, as discussed in more detail in Section 2.1.3 of this plan.
- Shaft No. 35 – Shaft No. 35 is the ore hoist shaft for the Casteel Mine. Ore is hoisted to the surface at this location, then placed at the ore storage/loading area located immediately north of the hoist.
- Ore storage/loading area – The ore storage/loading area is where ore from the Casteel Mine is stored and loaded onto trucks for transport to mills at other Doe Run facilities.
- Truck wash – The truck wash cleans vehicles leaving the facility. The truck wash is described in greater detail in Section 2.1.6 of this plan.

1.2 PLAN OBJECTIVES

As stated in the Master SWMP, the objective of the site-specific SWMPs is to evaluate the technical feasibility, practicality, and effectiveness of procedures and methodologies for management of process wastewater, mine water, and storm water associated with Doe Run mining and milling operations. The ultimate goal of this SWMP is to identify and employ water management strategies that lead to the discharge of effluent that meets applicable future final permit limits and conditions as specified in the Casteel facility’s Missouri State Operating Permit (MSOP).

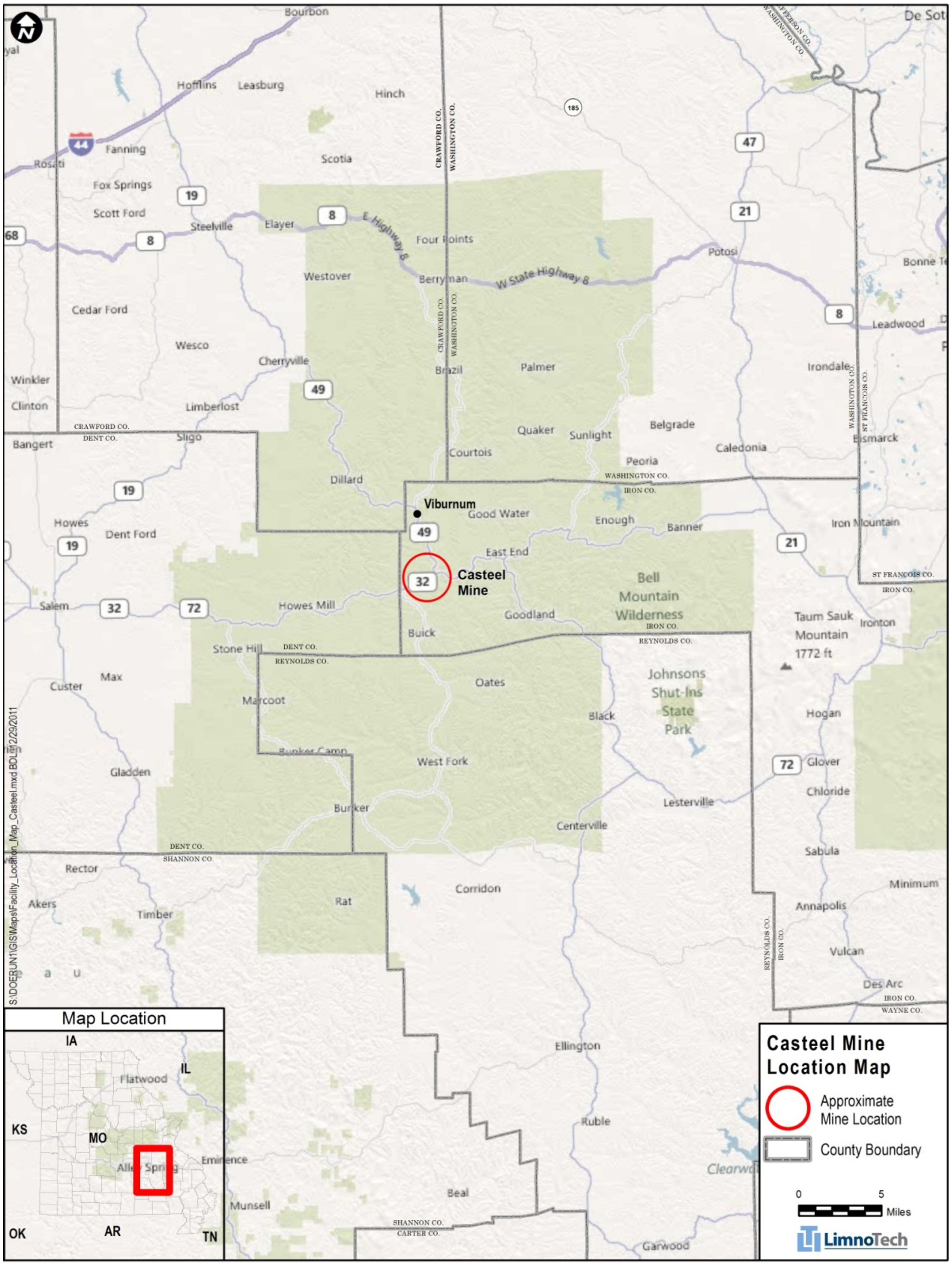


Figure 1-1. Location of the Casteel Mine.

Figure 1-2. Casteel Site Layout

(Note: Map orientation rotated to fit page).

1.3 SCOPE OF THE SWMP

The objective of this SWMP is to evaluate the management of water associated with Doe Run operations, specifically for the identification and implementation of actions that result in attainment of future final MSOP permit limits for the Casteel facility. As such, the scope includes sources, processes, flows, conditions and activities that can affect metals concentrations at permitted outfalls[1]. It does not address other potential environmental conditions at the facility.

1.4 CASTEEL SURFACE WATER MANAGEMENT TEAM

Surface water management for the Casteel facility will be the responsibility of the individuals named in Table 1-2. All of the individuals named are employees of The Doe Run Company.

Table 1-2. Casteel Surface Water Management Team.

Job Title	Name	Contact Info	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	#35 Iron County Rd. #1 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mill Manager	John Boyer	P.O. Box 500 Viburnum, MO 65566 573-689-4263	Oversight and management of Doe Run mill operations
Chief Engineer	Dan Buxton	P.O. Box 500 Viburnum, MO 65566 573-244-8142	Oversight of major water management measures evaluation and design
General Maintenance Manager	Gene Hites	P.O. Box 500 Viburnum, MO 65566 573-689-4151	Casteel surface water management plan primary oversight, implementation, and record-keeping
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573- 689-4535	Environmental data collection, management, and reporting
Casteel General Maintenance Supervisor	Bill Courtney	P.O. Box 500 Viburnum, MO 65566 573-626-2004	Casteel Surface Water Management Plan Secondary Oversight, Implementation, and Record-Keeping

[1] The SWMP focuses on the outfalls that convey flows from mining and milling operations. It should be noted that the Casteel facility has a permitted outfall #002 that is designated in the Casteel MSOP as a no-discharge domestic wastewater outfall. Outfall 002 is not discussed in this SWMP.

This page is blank to facilitate double sided printing.

2. WATER INVENTORY

As required by the Master SWMP, the components of surface water flow are discussed in detail in this section and their relative contributions to the overall water balance at the facility are presented. Each major surface water flow component is described in Section 2.1 and the overall facility surface water balance for each outfall is described in Section 2.2. The water inventory for the facility is characterized with respect to the two mine water outfalls at the facility: 001 and 003.

2.1 SURFACE WATER FLOW COMPONENTS

The major components of surface water flow for the Casteel facility are:

- Outfall flows
- Mine water
- Direct precipitation
- Evaporation
- Storm water runoff
- Truck wash water

Each of these flow sources is discussed below.

2.1.1 Outfall Flows

Monthly flow measurements have been manually collected by Doe Run at the mine water basin outfalls 001 and 003[2] since January 2005. Through February 2012, 86 measurements have been collected at each outfall. The average flow measurement for outfall 001 for this period was 2.7 MGD and the average flow measurement for outfall 003 was 5.3 MGD. These data are shown in Figure 2-1.

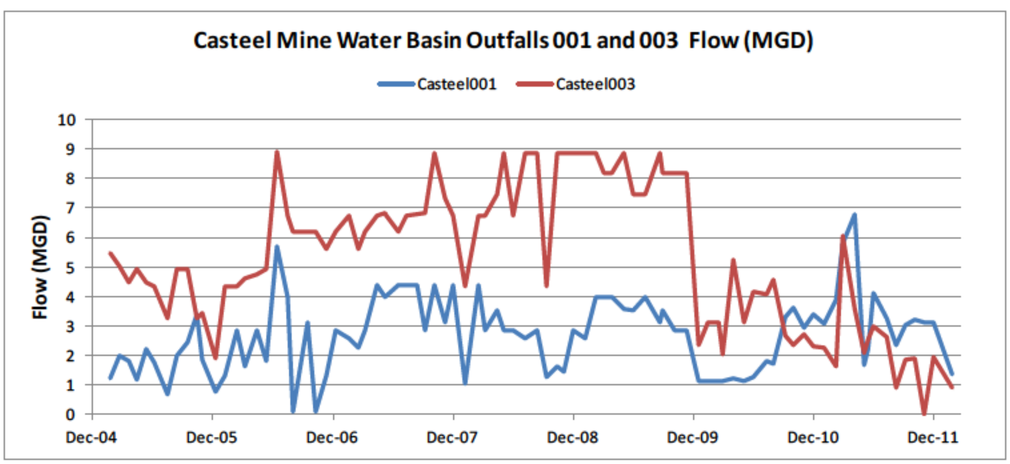


Figure 2-1. Measured Outfall Casteel Flows (Jan. 2005 through Jan. 2012).

[2] The outfalls for the Casteel mine water basins are numbered 001 and 003; samples and flow measurements collected from these outfalls have been assigned sample location identification numbers Casteel001 and Casteel003.

The average, minimum and maximum flows for each month of the year were calculated from these data and are presented in Table 2-1.

Table 2-1. Monthly Outfall Flows for the Casteel Facility.

	Casteel Outfall 001			Casteel Outfall 003		
Month	Ave	Min	Max	Ave	Min	Max
Jan	1.78	1.03	3.07	4.52	0.89	8.87
Feb	2.93	1.14	4.38	5.05	1.62	8.87
Mar	2.87	1.14	5.82	5.48	2.05	8.18
Apr	3.42	1.18	6.79	5.85	3.58	8.18
May	2.44	1.14	3.98	5.39	2.10	8.87
Jun	3.38	1.29	5.70	5.84	2.97	8.94
Jul	2.95	0.68	4.38	5.70	2.65	8.87
Aug	2.37	0.10	4.38	5.72	0.90	8.87
Sep	2.80	1.29	3.52	5.01	1.84	8.18
Oct	2.74	0.10	4.38	5.66	1.92	8.87
Nov	2.39	1.32	3.15	5.16	0.00	8.87
Dec	2.64	0.76	4.38	4.34	1.91	8.87

The average monthly flows for each Casteel outfall are shown graphically in Figure 2-2, using the 2005 – 2012 data.

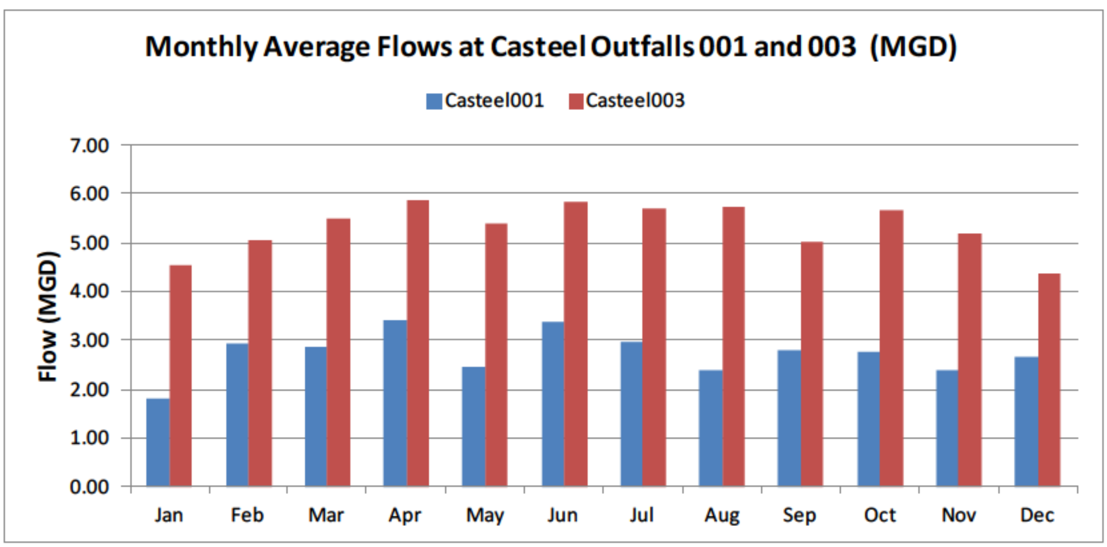


Figure 2-2. Monthly Average Flows at Casteel Outfalls 001 and 003.

The following observations can be made from these data:

- Flows from basin 003 are significantly higher than flows from basin 001; on average, about twice as much flow is discharged from outfall 003 as from outfall 001.
- In general, flows show a slight decline in winter; this effect is likely due to lower precipitation in December and January. This is more pronounced in the outfall 003 data than in the outfall 001 data.
- Flows from outfall 003 have been significantly lower starting in December 2009, than they were in the preceding three years. No specific reason for this was identified, but it is known that mine water flows generally vary with mining operations; different parts of the mine can yield different flows.

In addition to comparing flow between the two outfalls, the total outfall flow record (sum of flows at outfalls 001 and 003) was evaluated. The average total flow for January 2005 through January 2012 was 7.7 MGD, with a range from 1.3 to 14.6 MGD. However, as noted above, total mine water flows have been significantly lower since December 2009 than they were in the preceding years. These recent data are likely more representative of current operating conditions and mine water flows at the facility. The average total mine water flow rate for the period since December 2009 is 5 MGD. The average mine water flow at each outfall for this period was 2.7 MGD.

2.1.2 Mine Water

Most mine water from Casteel Mine is pumped to the surface at the mine water box, shown in Figure 1-2. At the mine water box, flow is split to the two mine water basins, 001 and 003. Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Casteel Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-2, as reported in the *Underground Water Management Plan for Casteel Mine* (LimnoTech, 2012).

The average mine water and outfall flows described above reflect historical conditions. However, a new mine water sump, called the V10 sump, was recently constructed in Casteel Mine to provide additional dewatering capacity in support of planned mining activities. Mine water pumped from the V10 sump is piped above ground to mine water basin 003.

The V10 sump became fully operational on January 27, 2012. It has three pumps, each capable of approximately 1,280 gpm. With current mine water flows, one pump currently operates constantly, a second operates about half of the time, and the third pump is an operational spare, used in the event that one of the other pumps requires maintenance or repair. Flow rates are monitored, but are not currently recorded. The V10 sump is currently pumping at a rate of approximately 1,800 gpm on average.

Table 2-2. Mine Water Flowrates at Casteel Mine, as Estimated by Mine Personnel.

Quantity	Value
Average Flow Pumped to Surface (before V10 sump)	2,800 gpm (4 MGD)
Maximum Mine Water Pumping Capacity (before V10 sump)	4,000 gpm (5.8 MGD)
Average Flow Currently Pumped to Surface from V10 sump	1,800 gpm (2.6 MGD)
Maximum Mine Water Pumping Capacity (with V10 sump)	7,000 gpm (10.1 MGD)

Mine water flow rates to each basin at Casteel are not measured. Comparison of the estimated average historical mine water flow (4 MGD) to the total average historical discharge flow from the outfalls (5 MGD) shows that the average combined outfall flows are about 25% higher than the estimated average mine water flows. There are three possible reasons for this:

1. The additional flows to the mine water basins (direct precipitation and storm water runoff) account for the difference.
2. The estimate of mine water pumping rates is too low.
3. The outfall flow measurements are monthly measurements and provide only a snapshot of flow at the time of measurement, therefore they may result in overestimation of flows.

It is possible that all of these factors contribute to the discrepancy. With the V10 sump operating, the average mine water flow at Casteel is expected to increase by 2.6 MGD. Mine water collected at the 86 sump, which was previously pumped to the Buick mine, has been diverted to the Lower Main Sump after excess capacity was created there by the new V10 sump project. Other flows to the mine water basins are discussed in the following sections and an overall water balance for each mine water basin is presented in Section 2.2.

2.1.3 Precipitation

Precipitation is important in understanding both direct volume contribution to the mine water basins and in calculating storm water flows. Rainfall data are not collected at the Casteel facility, so nearby sources of rain data must be used. There are two main uses for these data in this and other Doe Run SWMPs. First, the data are used to define long-term average rainfall on a monthly or annual basis. This requires a relatively long period of record, usually decades. Second, rainfall data are used to evaluate recently measured flow responses at Doe Run facilities as a way of corroborating runoff calculations. This requires current data collected at relatively high frequency, at least hourly. The sources of rainfall data nearest to the Casteel facility include:

- Brushy Creek rain gage – Doe Run has operated a rain gage at the Brushy Creek Mill facility since 2009.
- Buick Recycling rain gage – Rain data has been collected at the Buick Recycling facility since 2005.
- National Climatic Data Center (NCDC) Viburnum gage (#238609) – The NCDC has operated a rain gage in Viburnum since 1971.
- NCDC Salem gage (#237506) – The NCDC has operated a rain gage in Salem since 1979.

These rain gages are summarized in Table 2-3. The locations of these four gages relative to the Casteel facility are shown in Figure 2-3. Based on their relatively long periods of record, either of the NCDC gages could be used to calculate long-term average values. The Brushy creek gage has been recording only since 2009, which is insufficient for determining long-term averages.

Based on the proximity to the site, the Buick Recycling gage would be preferable for calculating storm water runoff response under wet weather conditions.

Table 2-3. Summary of Rain Gages Near Casteel Facility.

Rain Gage	Period of Record	Data Frequency	Distance to Casteel Mine Water Basins (miles)
Doe Run Brushy Creek	2009 – 2012	15 minute	8.3
Doe Run Buick Recycling	2005[3] – 2012	Hourly (2005-2012)	2.0
NCDC Viburnum (#238609)	1971 – 2011	15 minute	3.6
NCDC Salem (#237506)	1979 - 2011	15 minute	22.7

Inspection of the gage data from the two NCDC gages shows that each gage has had several years when data were only recorded for part of the year. In fact, only nine of the 40 years of operation for the Viburnum gage had a complete data set and only 11 out of 32 years at the Salem gage had a complete data set. Using only the complete data years, the Salem gage had a long-term average rainfall of 37.4 inches and the Viburnum gage had a long-term average rainfall of 38.7 inches. The average of these two is 38 inches.

[3] Older daily data exist, but were not compiled for this SWMP.

Using the average annual rainfall value of 38 inches, the volume contribution of direct precipitation to the Casteel mine water basins can be calculated, as shown in Table 2-4.

Table 2-4. Calculation of Average Annual Direct Precipitation to the Casteel Mine Water Basins

Mine Water Basin	Surface Area (acres)	Average Annual Rainfall (in)	Average Annual Rainfall Volume (MG)	Average Daily Rainfall Flow (MGD)
Basin 001	2.0	38	2.06	0.006
Basin 003	2.8	38	2.89	0.008

2.1.4 Evaporation

The mine water basins have relatively large, exposed water surfaces that are subject to volume loss by evaporation. Evaporation data were obtained from the NCDC Lakeside Station, which has a period of record from 1948 to 1990. This station was located approximately 100 miles from the Casteel facility. The average annual free water surface evaporation calculated from these data is about 38 inches per year, which is at the low end of the range for Missouri (Drew and Chen, 1997). This average also happens to be equal to the long-term average annual rainfall for the mine water basins. For purposes of the overall annual water balance, this annual evaporation rate was converted to a daily “flow” as shown in Table 2-5.

Table 2-5. Calculation of Average Annual Evaporation from the Casteel Mine Water Basins

Mine Water Basin	Surface Area (acres)	Average Annual Evaporation (in)	Average Annual Evaporation Volume (MG)	Average Daily Evaporation “Flow” (MGD)
Basin 001	2.0	38	2.06	0.006
Basin 003	2.8	38	2.89	0.008

The estimated average annual evaporation rate (38 inches) is equal to the estimated average annual rainfall for Casteel. Although these two quantities are equal, they do not occur at the same time and do not necessarily cancel each other out in the water balance, except on an annual basis.

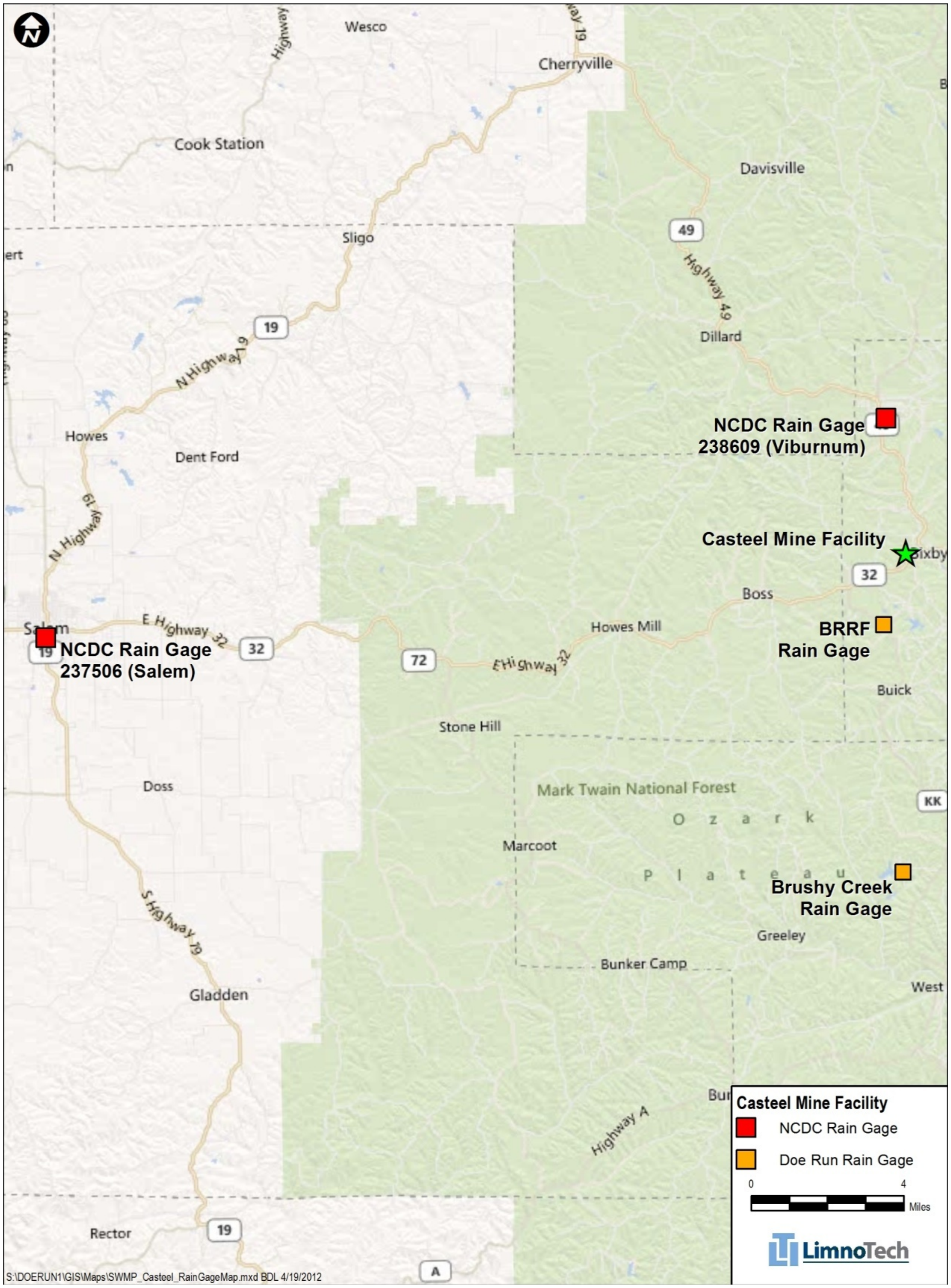


Figure 2-3. Nearest Rain Gages to the Casteel Facility.

2.1.5 Storm Water Runoff

Storm water provides a source of flows to the mine water basins at the Casteel facility. As shown in Figure 2-4, the drainage areas contributing storm water flows to the mine water basins are relatively small. Mine water basin 001 has a drainage area of approximately 7.8 acres and mine water basin 003 has a drainage area of approximately 37.9 acres.

A USEPA Storm Water Management Model (SWMM) was constructed to simulate storm water runoff to the Casteel mine water basins from their contributing drainage areas. The drainage areas to mine water basins 001 and 003 were individually delineated in ArcGIS using 10-meter elevation data. Soils, land use, and slope data were used to calculate a runoff curve number for each drainage area and these data were input into SWMM.

Rain data from the Buick Recycling rain gage for the period of September 2010 through April 2012 was used in the Casteel SWMM model to simulate runoff and to calculate and average runoff/rainfall ratio, which is an estimate of the average portion of rainfall that becomes runoff to the mine water basins. This ratio will vary with rainfall intensity but the average value is a reasonable indicator of the average runoff flow to the basins. This approach resulted in an average runoff/rainfall ratio of 0.27. If this ratio is applied to the long-term average annual rainfall discussed in the preceding section, a long-term average annual runoff contribution to the mine water basins can be calculated. Using this approach, the long-term average annual rainfall of 38 inches was used with the model-derived runoff/rainfall ratio and the drainage area of each mine water basin to calculate average annual runoff flows, as summarized in Table 2-6.

Table 2-6. Calculation of Average Annual Runoff Flows to the Casteel Mine Water Basins

Mine Water Basin	Drainage Area (acres)	Average Annual Rainfall (in)	Average Annual Rainfall Volume (MG)	Runoff/ Rainfall Ratio	Average Annual Runoff Volume (MG)	Average Daily Runoff Flow (MGD)
Basin 001	7.8	38	8.05	0.27	2.17	0.004
Basin 003	37.9	38	39.1	0.27	10.56	0.029

The model was then run for a suite of design storms of 24-hour duration, summarized in Table 2-7, to evaluate the variability of the runoff/rainfall ratio.

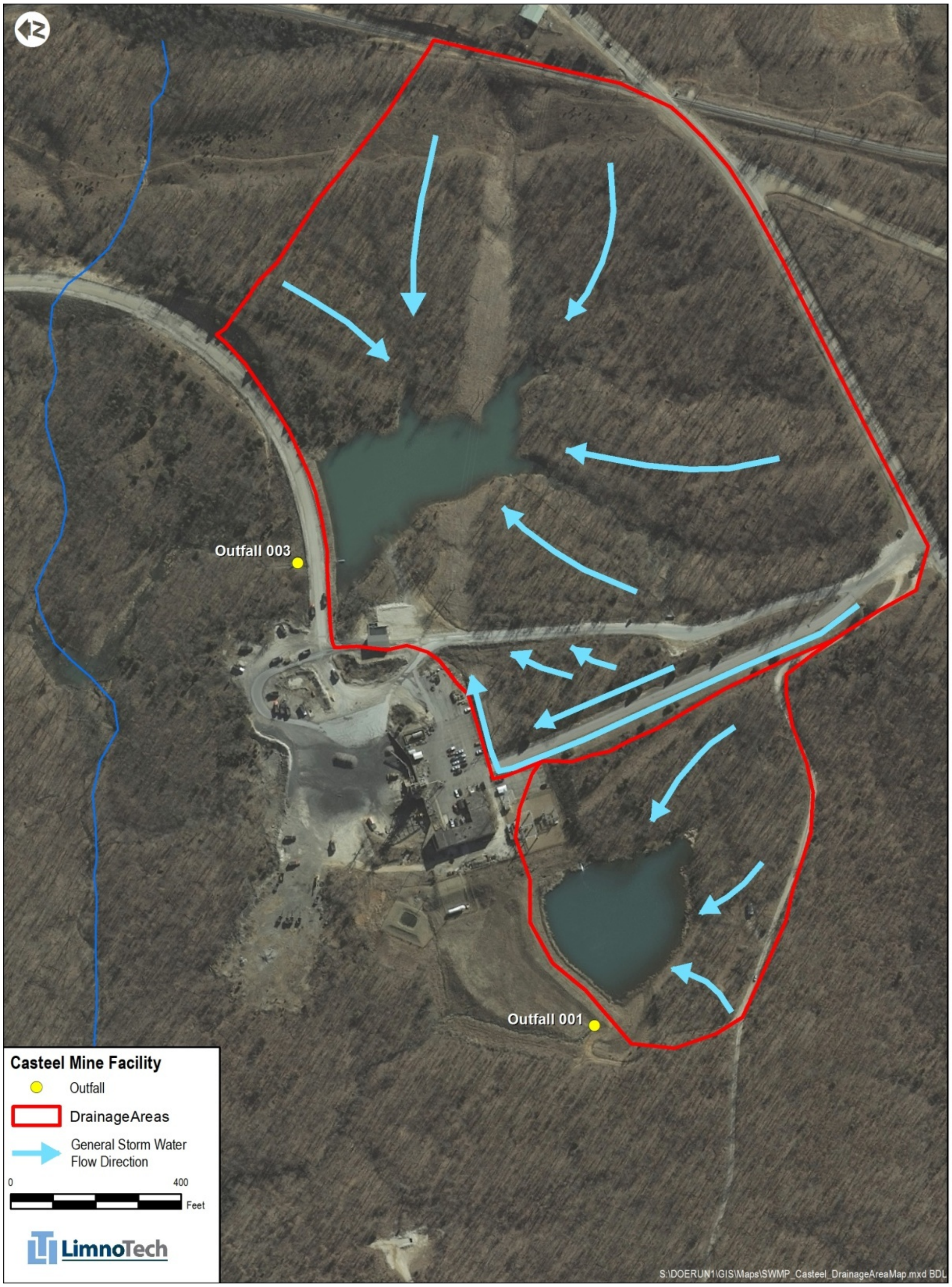


Figure 2-4. Storm Water Drainage Areas and Flow Paths at Casteel Site
(Note: Map orientation rotated to fit page).

Table 2-7. Characteristics of 24-hour Storm Events (Huff and Angel, 1992) and Variation of Runoff/Rainfall Ratios

Recurrence (years)	Duration (hours)	Rainfall Depth (inches)	Model-Derived Runoff/ Rainfall Ratio
1	24	2.79	0.25
2	24	3.51	0.34
5	24	4.39	0.42
10	24	5.03	0.46
25	24	5.94	0.52

These results show that the runoff/rainfall ratio will increase with storm intensity and can be nearly twice the long-term average.

2.1.6 Truck Wash Water

Water for the Casteel truck wash is mine water that flows by gravity from the mine water box. During the truck washing process, water is collected in floor drains inside the truck wash building and drained to a concrete settling basin on the east side of the building. This allows solids to settle and the clarified water is then discharged back to mine water basin 003. The truck wash process is, therefore, a closed-loop process and does not represent either a net gain or loss with respect to the flow through mine water basin 003.

The truck wash is designed to spray each truck for a minimum of 45 seconds at a flow of 500 gpm to 1,000 gpm, therefore a reasonable estimate of the truck wash water usage is 700 gallons per truck. Records at the Casteel facility indicate that the average number of trucks leaving Casteel and passing through the truck wash monthly is about 2,730 for an annual average of about 32,760 trucks per year. At 700 gallons per truck, this means that approximately 23 million gallons of water are withdrawn from the basin, cycled through the truck wash and discharged back to basin 003 every year, for an average daily flow of 0.063 MGD.

As mentioned above, this is a closed loop process and does not represent a net increase in flow through the basin. However, truck wash water may represent a net increase in solids loading to the basin, which may affect metals concentrations. The impact of discharging truck wash water into mine water basin 003 at Casteel is discussed in Section 3.3.3 of this plan.

2.2 FACILITY WATER BALANCE

The calculations of flows to and from the Casteel mine water basins, described in the preceding sections of this plan, were combined to produce an overall water balance for the basins. These individual flows are summarized in Table 2-8 and the total inflow volumes and outflow volumes are provided for comparison.

As can be seen from the comparison in Table 2-8, there is a difference of nearly 1 MG in the annual inflow and outflow volumes for the Casteel mine water basins. The magnitude of this discrepancy is much larger than the estimated values for direct precipitation, storm water runoff, and evaporation. Therefore, the difference must be attributable to underestimation of mine flows, overestimation of outfall flow, or a combination of the two.

The outfall data collected and described in Section 2.1.1 show that sometimes flows from basin 001 are larger than flows from basin 003, and sometimes the opposite is true. However, the average measured flow from each outfall from December 2009 to January 2012 was 2.7 MGD, which suggests that the average flows from the mine water basins are approximately equal under present operating conditions. This information can be used to distribute the flow discrepancy between the two mine water flows, so that the corrected mine water flow into basin 001 is 2.496 MGD and the corrected mine water flow into basin 003 (not including V10 sump flows) is 2.471 MGD. These are only estimates of the average mine water flows into the basins, but they are necessary adjustments for purposes of balancing flows.

Table 2-8. Summary of Flows for Casteel Mine Water Basin Water Balance Prior to V10 Sump Operation

Inflow	Outflow
Mine Water (4 MGD)	
Direct Precipitation (0.014 MGD)	
Storm Water Runoff (0.033 MGD)	
	Evaporation (-0.014 MGD)
	Discharge (-5 MGD)
4.047 MGD	-5.014 MGD

A schematic of the water balance for the Casteel mine water basins, which now includes the mine water flows from the V10 sump, is presented in Figure 2-5. It is important to note that mine water is, by far, the major source of flow to the mine water basins on an annual basis. On average, mine water flows are more than 30 times storm water flows to the basins. This indicates that managing storm water volumes is likely to have little effect on effluent quality form the basins.

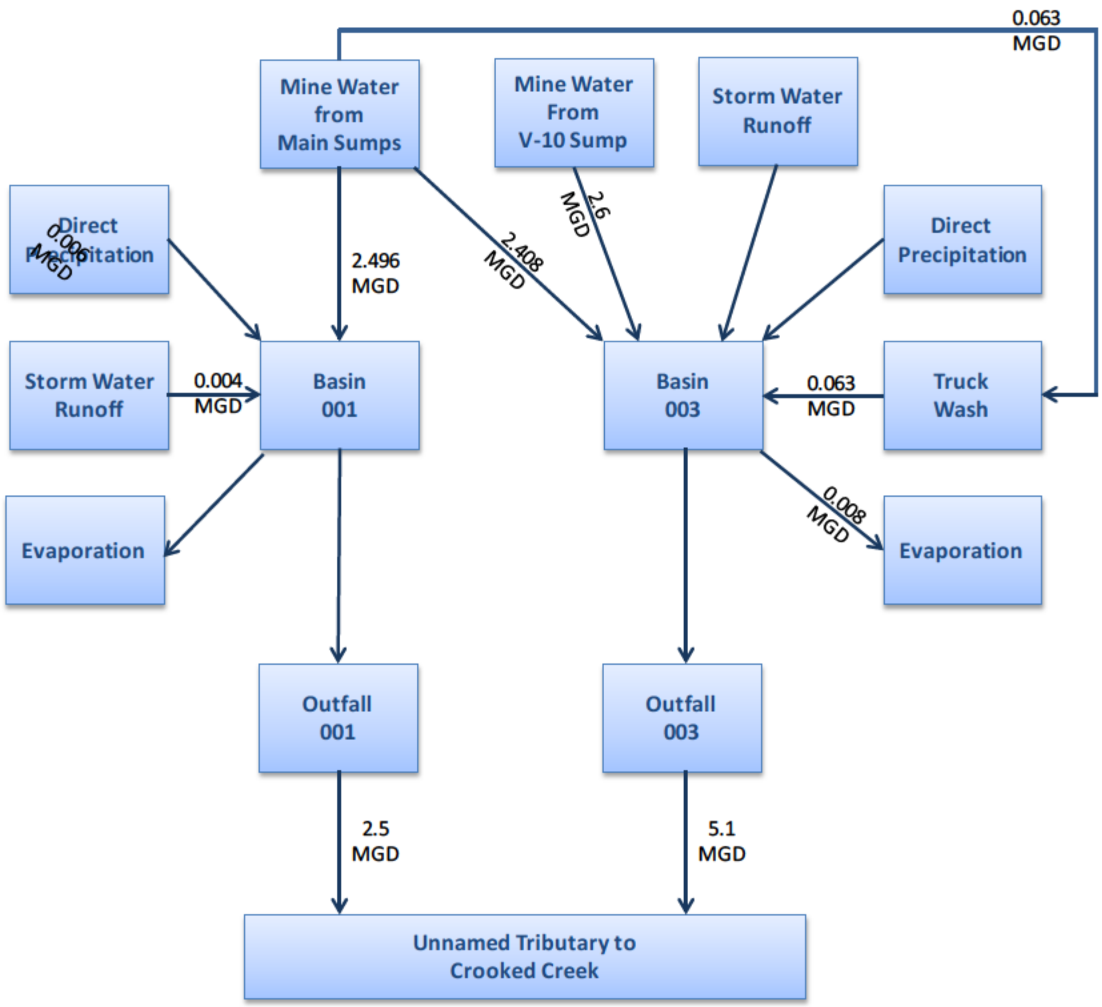


Figure 2-5. Overall Water Balance for Casteel Mine Water Basins.

3. SOURCE IDENTIFICATION

As stated in the Master SWMP (LimnoTech, 2011a), the source identification component of the Site-Specific SWMP involves identifying and investigating the potential sources of target metals to surface water at each facility and identifying the pathways by which metals might enter surface water flows. This section of the Casteel SWMP describes the following components of the source identification process at the facility:

- Surface Water Data Summary – An overview of the data used in this SWMP.
- Outfall Data Assessment – A review of outfall monitoring data to identify priorities for the Surface Water Management Plan.
- Sources of Metals Loading to Outfalls – Describes each potential source of metals loading to the outfalls: mine water, storm water runoff, and truck wash water.
- Source Assessment Summary – Summarizes the sources evaluated for the Casteel facility and presents conclusions.

Further discussion of the fate and transport of metals from these sources is presented in Section 4 of this plan.

3.1 SURFACE WATER DATA SUMMARY

The analysis to support the Casteel SWMP relies on data from three different sampling efforts, which are described in greater detail below:

- Monthly outfall sampling as required by the Casteel facility's MSOP.
- Sampling conducted specifically for the SWMP in March-May 2011, as outlined in the Surface Water Sampling and Analysis Plan (LimnoTech, 2011b).
- Supplemental semi-monthly sampling conducted since September 2011 to support SWMP preparation.

Stations Casteel001 and Casteel003 pertain to outfalls 001 and 003, which are the outlets for mine water basins 001 and 003[4]. Water in these basins consists of mine water, storm water runoff, and truck wash water (003 only). Monthly sampling is required at these two locations to comply with MSOP requirements. Sampling for total metals and solids was conducted at outfalls 001 and 003 since January 2005, with sampling occurring approximately once/month. Analysis of dissolved metals began in January 2006.

Sampling conducted specifically for the Casteel SWMP was documented in a surface water sampling and analysis plan (SWSAP) report in 2011 (LimnoTech, 2011c).

[4] As stated in Section 1, the Casteel SWMP focuses on the outfalls that convey flows from mining operations. The Casteel facility has a permitted outfall #002 that is designated in the Casteel MSOP for only domestic wastewater, but Outfall 002 is not discussed in this SWMP.

Three discrete sampling events were conducted at Casteel on 3/1/2011, 4/14/2011, and 5/18/2011. Not every location was sampled during every event, but every location in Tables 3-1 and 3-2 was sampled during at least one event.

Beginning in September 2011, stations Casteel001, Casteel003, CS-MW001, and CS-MW003 were sampled twice/month to provide additional data in support of the Casteel SWMP. At each of these stations, one September 2011 semimonthly sample was analyzed for dissolved metals, and both were analyzed for total metals and total suspended solids (TSS). Beginning in October 2011, both semimonthly samples at each station were analyzed for all constituents. At the time of this report, semimonthly data have been received and validated through January 2012. These sample locations are shown in Figure 3-1.

Table 3-1. Surface Water Data Availability for Total Metals and Solids at Casteel Facility, by Station[5]

Station ID	Date Range (Total)	Date Range (TSS)	Count of Samples				
			Tot-Cd	Tot-Cu	Tot-Pb	Tot-Zn	TSS
Casteel001	1/2005-1/2012		117	115	113	116	115
Casteel003	1/2005-1/2012		119	116	119	114	116
CS-MW001	3/2011-1/2012		16	16	16	16	15
CS-MW003	3/2011-1/2012		16	16	16	16	16
CS-TWEFF	3/2011, 5/2011		2	2	2	2	2
CS-MWB001BOT	4/2011		1	1	1	1	1
CS-MWB001SUR	4/2011		1	1	1	1	1
CS-MWB003BOT	4/2011		1	1	1	1	1
CS-MWB003SUR	4/2011		1	1	1	1	1

Table 3-2. Surface Water Data Availability for Dissolved Metals at Casteel Facility, by Station[1]

Station ID	Date Range (Dissolved)	Count of Samples			
		Dis-Cd	Dis-Cu	Dis-Pb	Dis-Zn
Casteel001	1/2006-1/2012	76	76	76	76
Casteel003	1/2006-1/2012	77	77	77	77
CS-MW001	3/2011-1/2012	16	16	16	16
CS-MW003	3/2011-1/2012	16	16	16	16
CS-TWEFF	3/2011, 5/2011	2	2	2	2
CS-MWB001BOT	4/2011	1	1	1	1
CS-MWB001SUR	4/2011	1	1	1	1
CS-MWB003BOT	4/2011	1	1	1	1
CS-MWB003SUR	4/2011	1	1	1	1

[5] On-site sample locations only; receiving water sample locations are not listed.

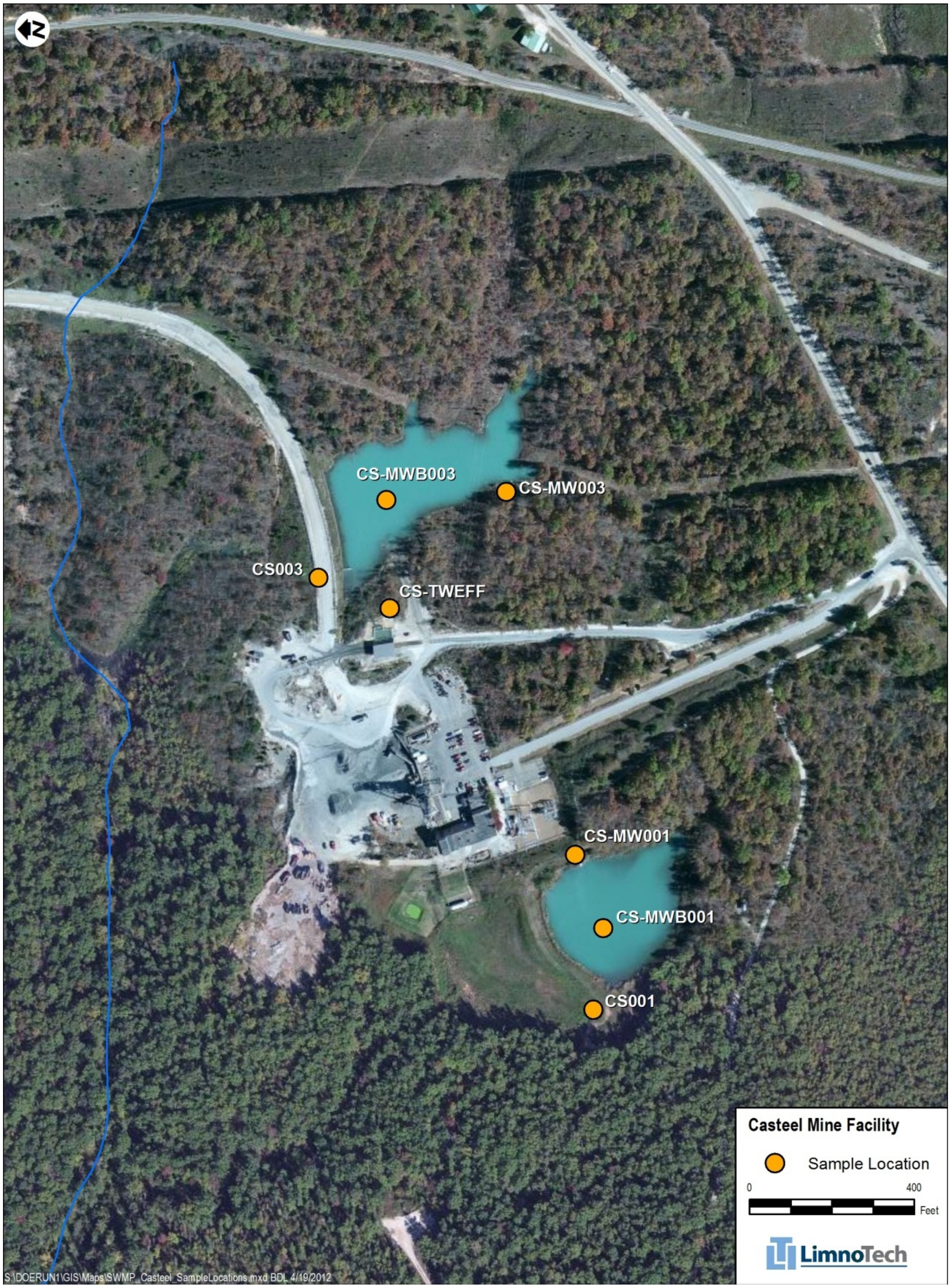


Figure 3-1. Casteel Surface Water Sample Locations

(Note: Map orientation rotated to fit page).

3.2 OUTFALL DATA ASSESSMENT

The primary objective of this SWMP is to evaluate procedures and methodologies for management of water with the ultimate goal of discharging effluent that meets applicable MSOP future final limits, therefore the Casteel outfall data were analyzed to identify priorities for water management. The following sections present the following evaluations:

- Comparisons of outfall data to future final MSOP limits
- Comparison of total and dissolved metals in effluent at the outfalls
- Evaluation of seasonal variability of the outfall data.

3.2.1 Comparison of Outfall Data to Future Final MSOP Limits

Effluent monitoring data from the Casteel mine water basins were evaluated in reference to the future final discharge limits in the MSOP for the Casteel Mine which become effective in March 2013. The future final limits for the primary constituents of interest for outfalls 001 and 003 are summarized in Tables 3-3 and 3-4, respectively.

Table 3-3. Future Final MSOP Limits for the Casteel Mine (Outfall 001)

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.6	0.8
Copper, total recoverable	300	150
Lead, total recoverable	48.2	24
Zinc, total recoverable	446.3	222.4

Table 3-4. Future Final MSOP Limits for the Casteel Mine/Mill Facility (Outfall 003)

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.2	0.6
Copper, total recoverable	137.2	68.4
Lead, total recoverable	59.4	29.6
Zinc, total recoverable	468.1	233.3

3.2.1.a Time Series Plots for Casteel Outfall Data

Time-series plots of total metals concentrations at outfalls 001 and 003 for cadmium, copper, lead, zinc, and TSS are presented on the following pages. Future final MSOP effluent limits are shown on the plots to facilitate comparison of data with those limits.

Total cadmium data are shown in Figure 2 and Figure 3 for outfalls 001 and 003, respectively for the time period of June 2010 through January 2012[6]. During the time period shown, four samples at outfall 001 were higher than both the future final daily maximum limit and future final monthly average limit, and nearly all (87%) samples were higher than the future final monthly average limit for cadmium at 001. During this time period, two samples were higher than both the future final daily and future final monthly limits at outfall 003 and nearly all (93%) samples were higher than the future final monthly average limit for total cadmium at 003.

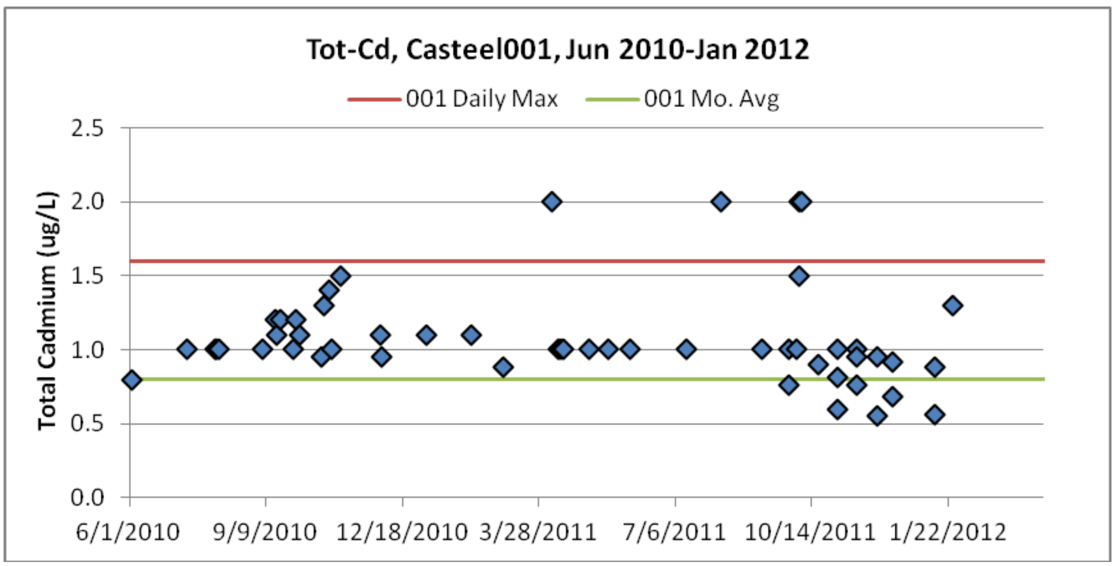


Figure 3-2. Time Series Plot for Total Cadmium at Casteel001, June 2010-January 2012

[6] These dates were selected because prior to June 2010, a detection limit of 5-10 µg/L was used for cadmium, which exceeds all MSOP limits for total cadmium.

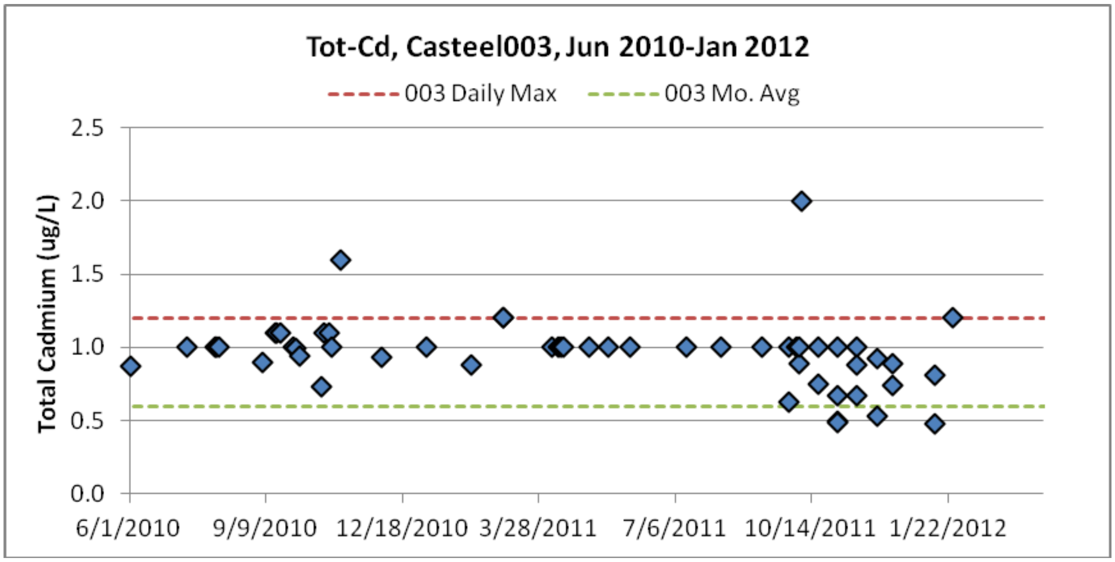


Figure 3-3. Time Series Plot for Total Cadmium at Casteel003, June 2010-January 2012

Total copper effluent data are shown in Figure 4 and Figure 5 for outfalls 001 and 003, respectively. Between January 2005 and January 2012, 100% of all effluent samples were below both the future final daily maximum and future final monthly average MSOP limits for total copper.

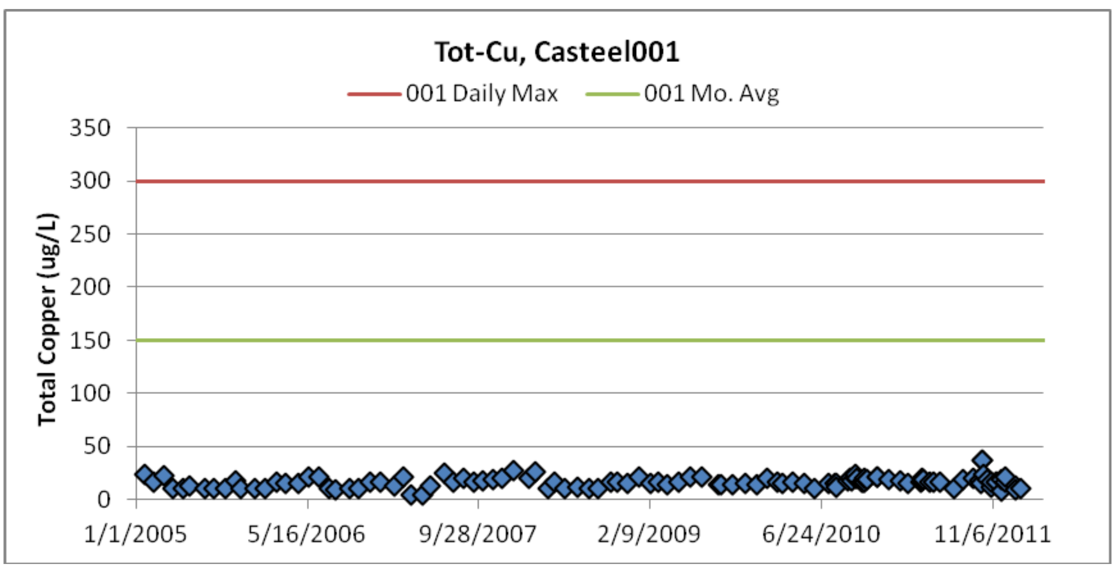


Figure 3-4. Time Series Plot for Total Copper at Casteel001

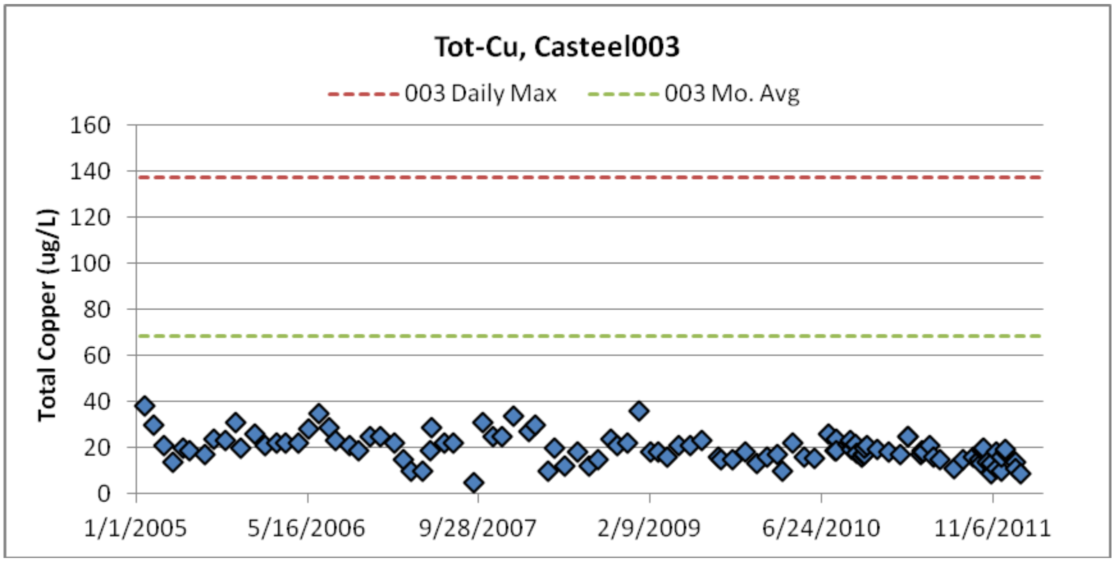


Figure 3-5. Time Series Plot for Total Copper at Casteel003

Total lead effluent data are shown in Figure 6 and Figure 7 for outfalls 001 and 003, respectively, between January 2005 and January 2012. At outfall 001, all but one sample were higher than the future final daily maximum limit and 100% of samples were higher than the future final monthly average limit for this time period. At outfall 003, 100% of samples were higher than both the future final daily and future final monthly effluent limits for total lead.

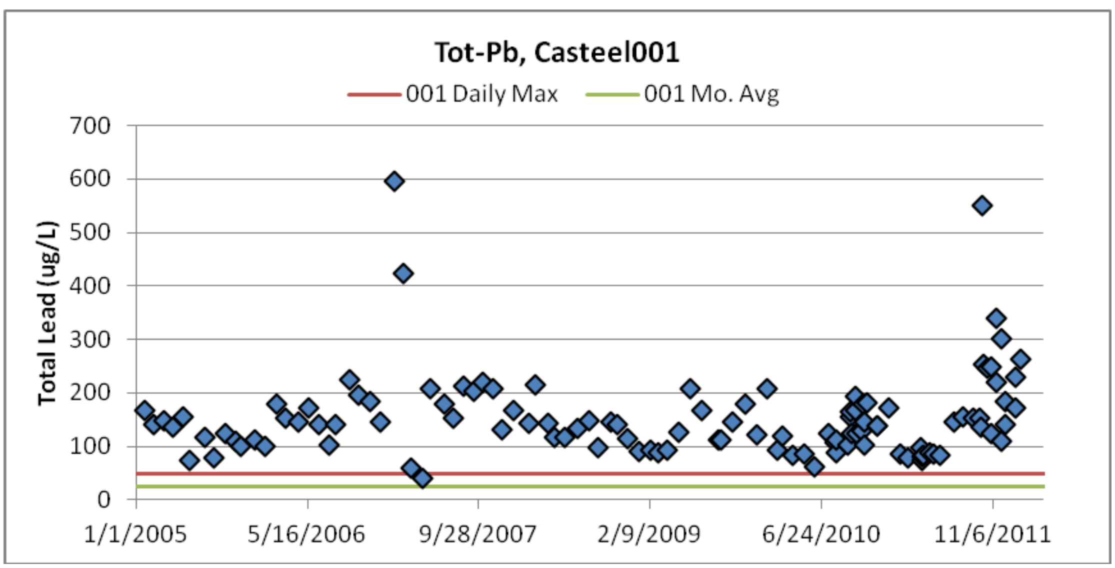


Figure 3-6. Time Series Plot for Total Lead at Casteel001

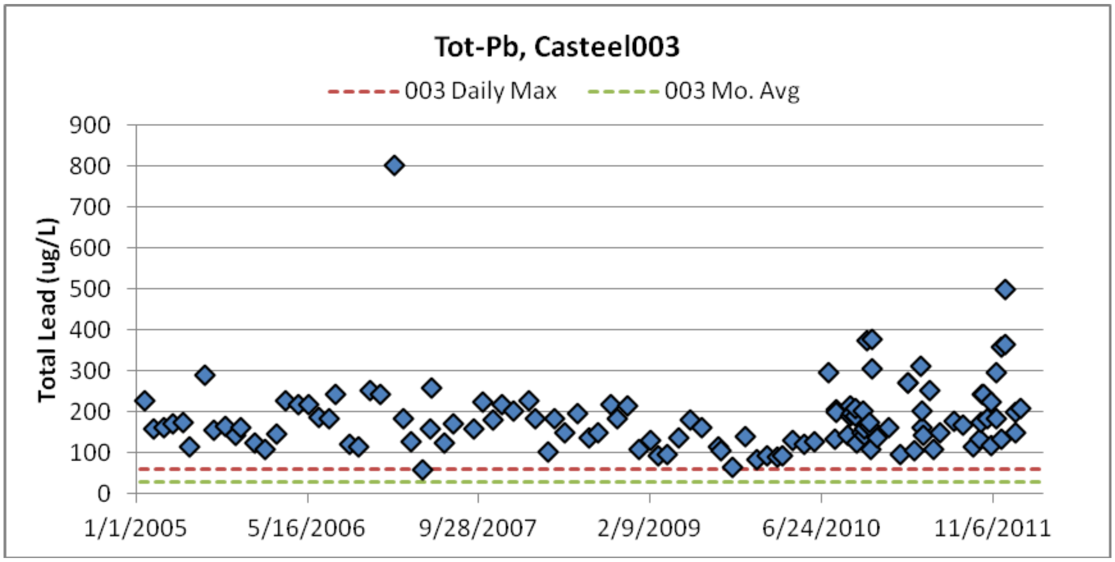


Figure 3-7. Time Series Plot for Total Lead at Casteel003

Figure 8 and Figure 9 show total zinc concentrations at outfalls 001 and 003, respectively, between January 2005 and January 2012. Data were mostly below the future final daily maximum and future final monthly average effluent limits, with three exceptions. One sample at outfall 001 was slightly higher than the future final monthly average limit in 2011 and one sample was higher than both future final limits in 2006. At outfall 003, two samples were higher than the future final monthly average limit, but all samples were below the future final daily maximum limit.

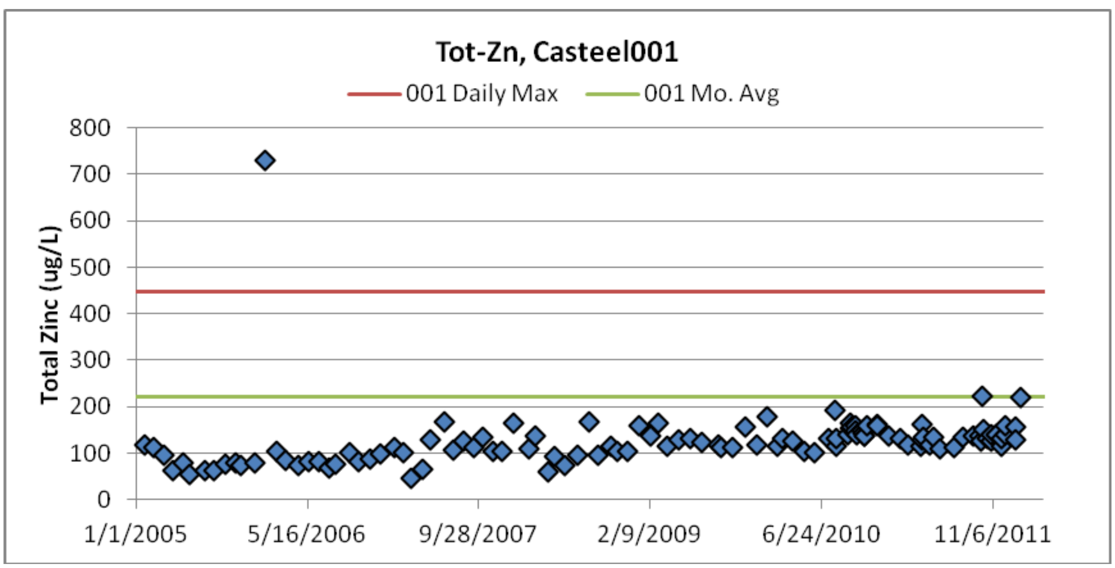


Figure 3-8. Time Series Plot for Total Zinc at Casteel001

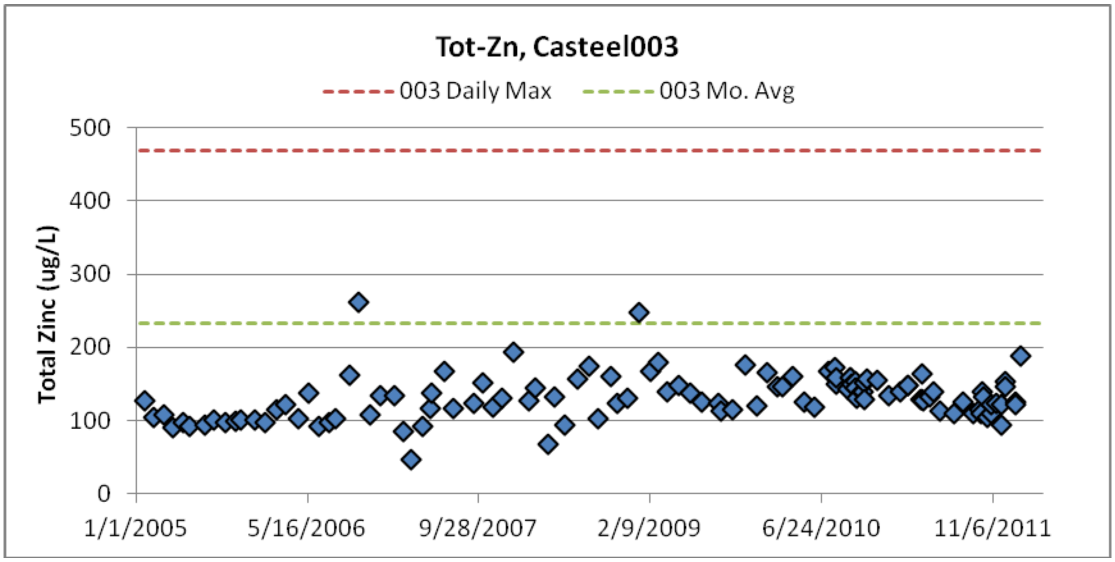


Figure 3-9. Time Series Plot for Total Zinc at Casteel003

TSS concentrations measured at outfalls 001 and 003 between January 2005 and January 2012 are shown in Figure 3-10 and Figure 3-11, respectively. During this monitoring period, only one sample was higher than the future final monthly average and future final daily maximum effluent limits for TSS at outfall 001; the rest of the data were all below the future final limits for TSS. At outfall 003, two samples were higher than both the future final daily maximum and future final monthly average effluent limits and two samples were higher than the future final monthly average limit.

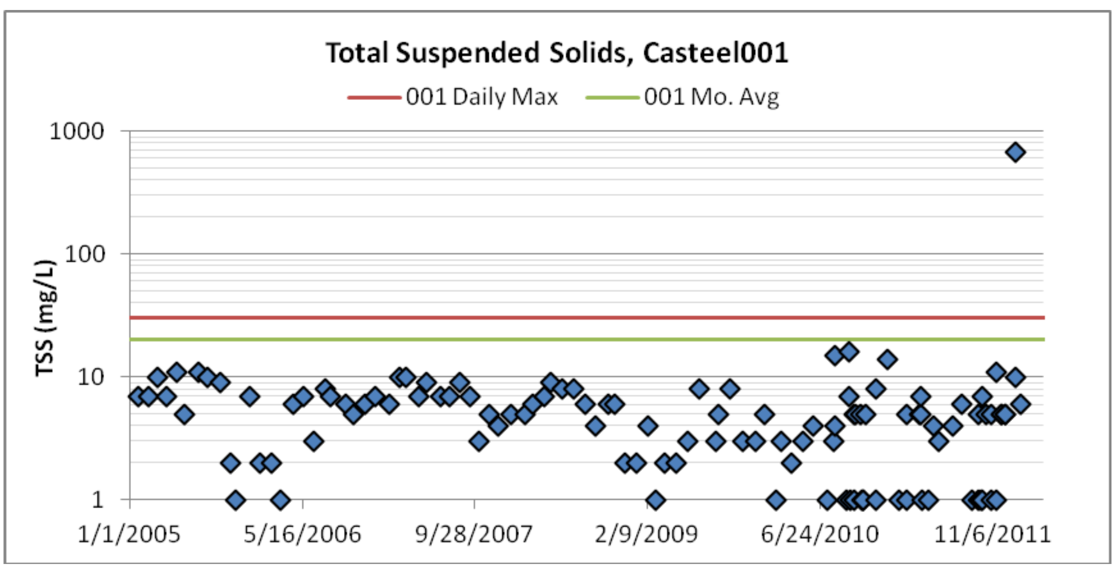


Figure 3-10. Time Series Plot for TSS at Casteel001

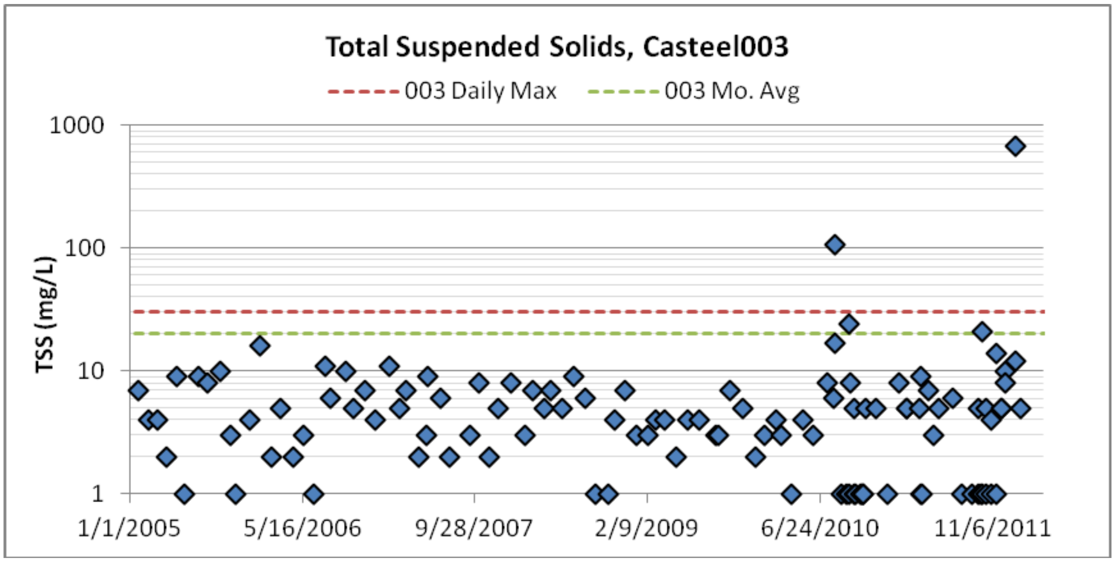


Figure 3-11. Time Series Plot for TSS at Casteel003

Tables 3-5 and 3-6 summarize the data presented in the preceding section, in terms of the number of samples and percent of samples exceeding future final MSOP limits for outfalls 001 and 003.

Table 3-5. Summary of Samples Higher Than Future Final MSOP Limit for Casteel Outfall 001.

Parameter	Total Samples	Monthly Avg Limit		Daily Max Limit	
		# Samples	% of Samples	# Samples	% of Samples
Tot-Cd	52*	45	87%	4	8%
Tot-Cu	115	0	0%	0	0%
Tot-Pb	113	113	100%	112	99%
Tot-Zn	113	2	2%	1	1%
TSS	115	1	1%	1	1%

*Only includes samples in June 2010 and later

Table 3-6. Summary of Samples Higher Than Future Final MSOP Limit for Casteel Outfall 003.

Parameter	Total Samples	Monthly Avg Limit		Daily Max Limit	
		# Samples	% of Samples	# Samples	% of Samples
Tot-Cd	54*	50	93%	2	4%
Tot-Cu	116	0	0%	0	0%
Tot-Pb	119	119	100%	119	100%
Tot-Zn	112	2	2%	0	0%
TSS	116	4	3%	2	2%

*Only includes samples in June 2010 and later

3.2.1.b Probability Plots for Casteel Outfall Data

Probability plots were developed for the Casteel outfall data to provide an alternate tool for evaluation of future final effluent limits attainment, using the effluent probability method (USEPA, 2009). These plots present rank-based cumulative probabilities of the outfall data with future final MSOP effluent limits included as vertical lines to facilitate comparison of data to the limits. The probability plots presented here reflect existing conditions and represent a possible indication of future conditions, if no action is taken to reduce metals loading to the mine water basin outfalls.

Probability plots for total cadmium for outfall 001 and outfall 003 are presented in Figure 3-11. As previously described, only data for the period of June 2010 to January 2012 were plotted for total cadmium because prior to June 2010, a detection limit of 5-10 µg/L was used for cadmium, resulting in numerous non-detect samples. These plots indicate that the probability of meeting the future daily maximum limit for total cadmium is about 90% at both outfalls and the probability of meeting the future final monthly average limit for total cadmium is about 10% at both outfalls, based on historical data.

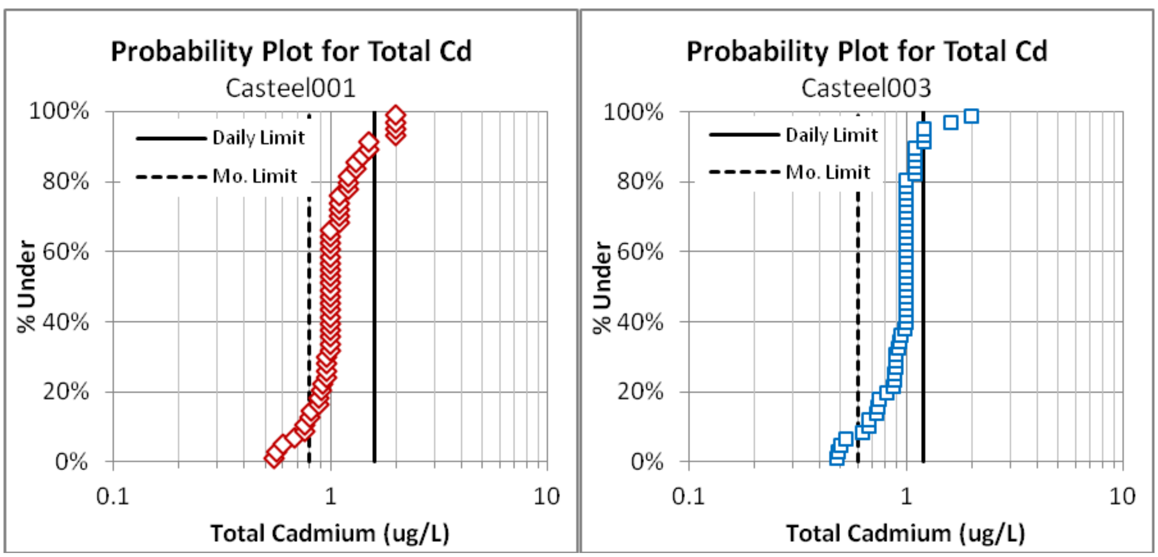
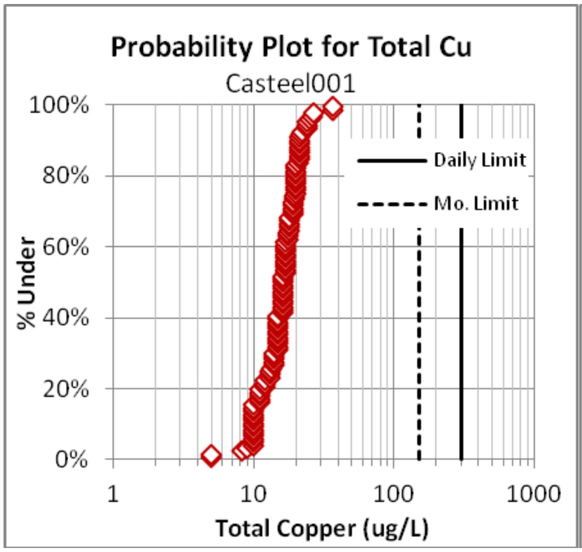


Figure 3-12. Probability Plots for Total Cadmium, Casteel001 and Casteel003.

Figure 3-12 presents probability plots for total copper for outfall 001 and outfall 003. These probability plots for total copper demonstrate that 100% of samples at both outfalls were in compliance with the MSOP future final effluent limits for total copper.



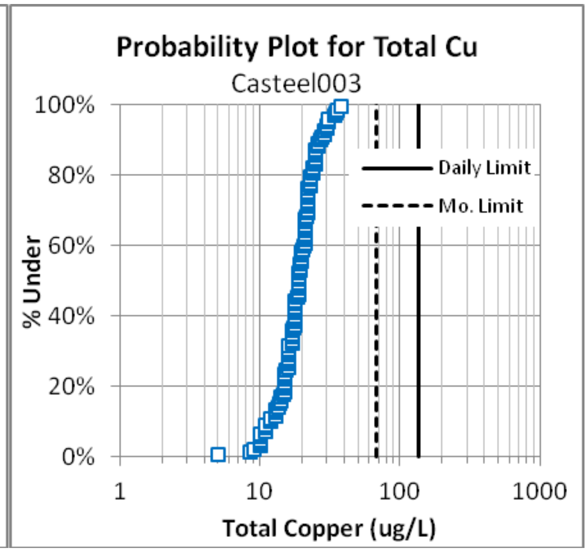
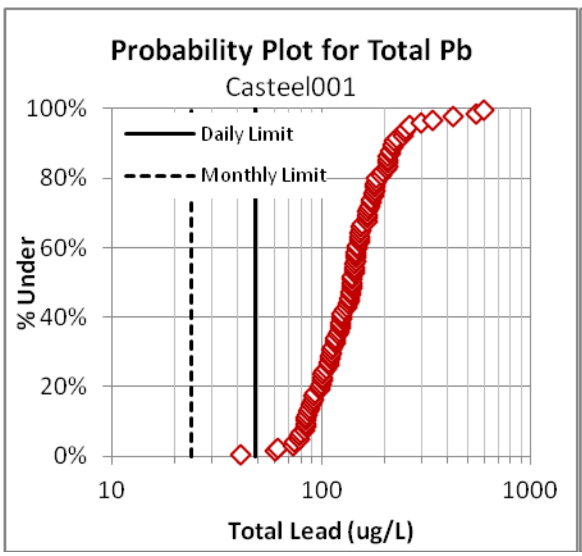


Figure 3-13. Probability Plots for Total Copper, Casteel001 and Casteel003.

Figure 3-13 presents probability plots for total lead for outfalls 001 and 003. These plots show that the probability of total lead in the effluent meeting future final effluent limits is less than 1% at outfall 001 and zero at outfall 003.



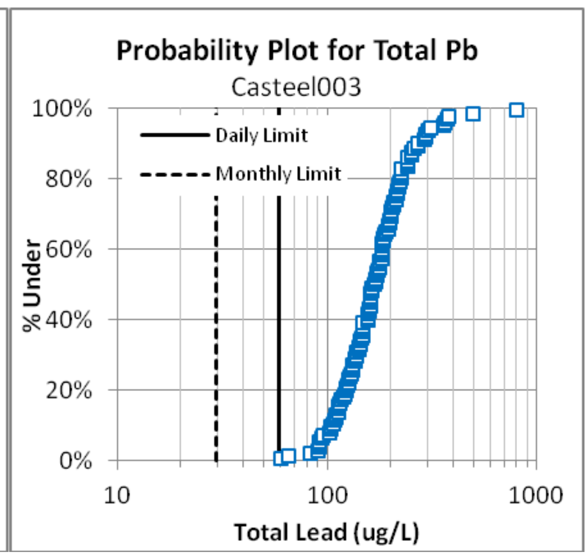


Figure 3-14. Probability Plots for Total Lead, Casteel001 and Casteel003.

Probability plots for total zinc at outfalls 001 and 003 are presented in Figure 3-14. These plots indicate that the probability of effluent attaining the future final effluent limits for total zinc at outfall 001 is about 98%. They also show that the probability of the effluent at outfall 003 meeting the future final daily maximum limit for total zinc is 100%, with a 99% probability of meeting the future final monthly average limit.

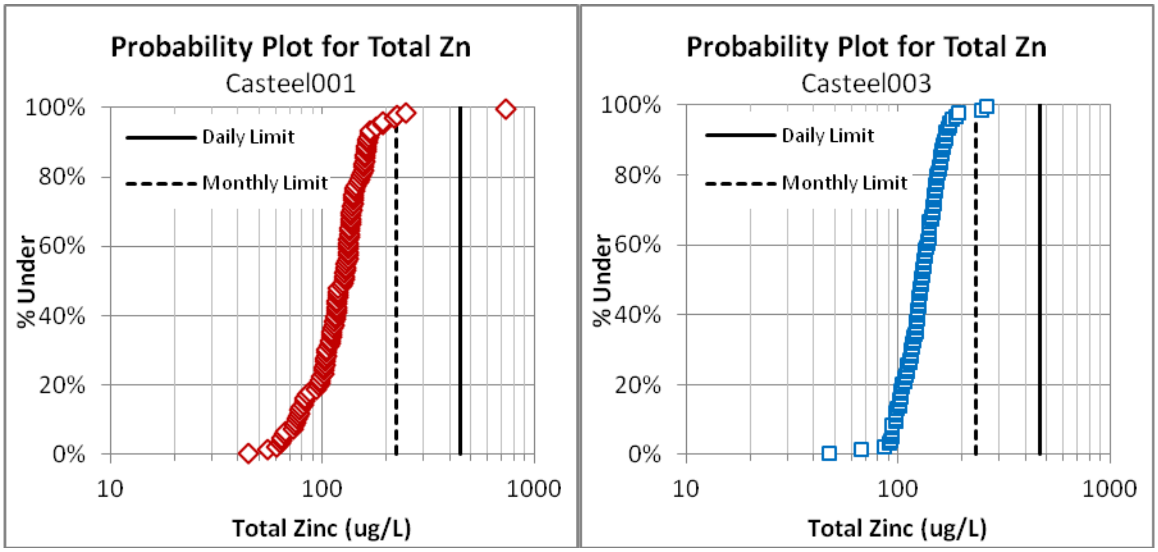


Figure 3-15. Probability Plots for Total Zinc, Casteel001 and Casteel003.

These analyses suggest that cadmium and lead are less likely than copper or zinc to attain their respective future final MSOP limits, assuming no additional treatment, and are therefore a higher control priority at Casteel.

In addition to concentrations of total lead and cadmium at the Casteel outfalls that are higher than the future final MSOP limits, effluent from the Casteel outfalls has historically failed to pass chronic whole effluent toxicity (WET) tests. Given the elevated concentrations of lead, it is expected that total lead concentrations are likely the cause of the effluent toxicity and that measures which result in reduced lead concentrations at the outfall will also result in the effluent passing chronic WET tests.

3.2.2 Seasonal Variability of Metals at Outfall

The Casteel outfall data were grouped by month for each metal to provide a graphical way to observe seasonal variations in the data. Box-and-whisker plots ("box plots") were prepared to show variation from month to month[7]. The future final MSOP limits are provided for comparison with the data.

Figure 3-15 shows monthly box plots for measured total cadmium concentrations at outfall 001 and Figure 3-16 shows a similar plot for total cadmium at outfall 003. The utility of the plot is limited due to the high number of non-detect samples (prior to June 2010, higher detection limits of 5 µg/L and 10 µg/L were used). However, there is insufficient data between June 2010 and January 2012 to construct monthly box plots for total cadmium, so the entire dataset was used.

[7] Box plots depict the median effluent concentrations, along with the upper and lower quartiles (top and bottom of box, respectively) and the minimum and maximum recorded values (upper and lower ends of whiskers).

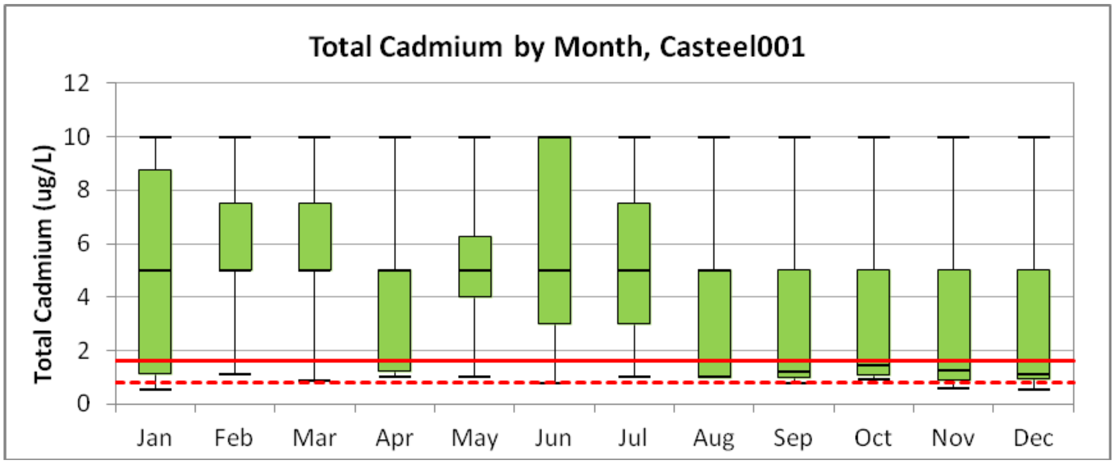


Figure 3-16. Monthly Box Plots for Total Cadmium at Casteel001.

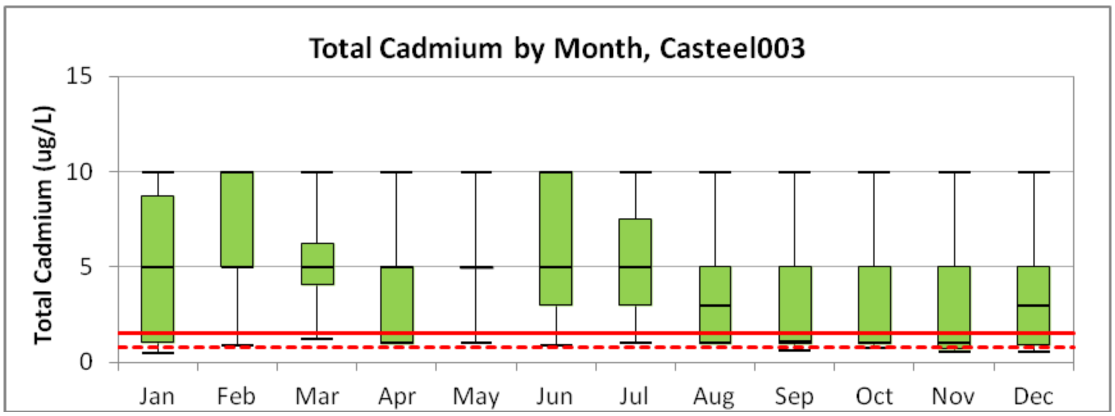


Figure 3-17. Monthly Box Plots for Total Cadmium at Casteel003.

Due to the high number of non-detect values and the low range of values measured, it is not possible to draw any conclusions about seasonal variability of total cadmium from these data.

Box plots for total copper are presented in Figure 3-17 and Figure 3-18 for outfalls 001 and 003, respectively. There appears to be little monthly variation at either outfall.

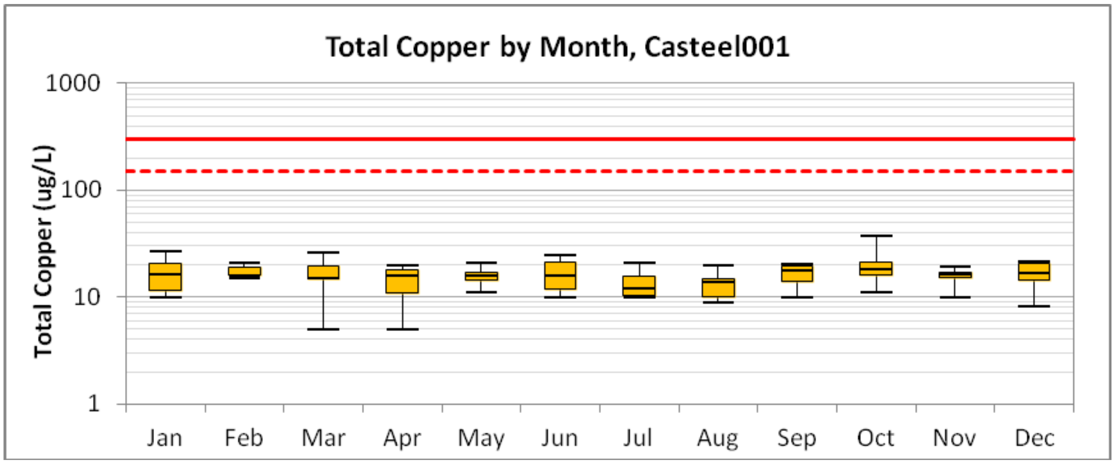


Figure 3-18. Monthly Box Plots for Total Copper at Casteel001.

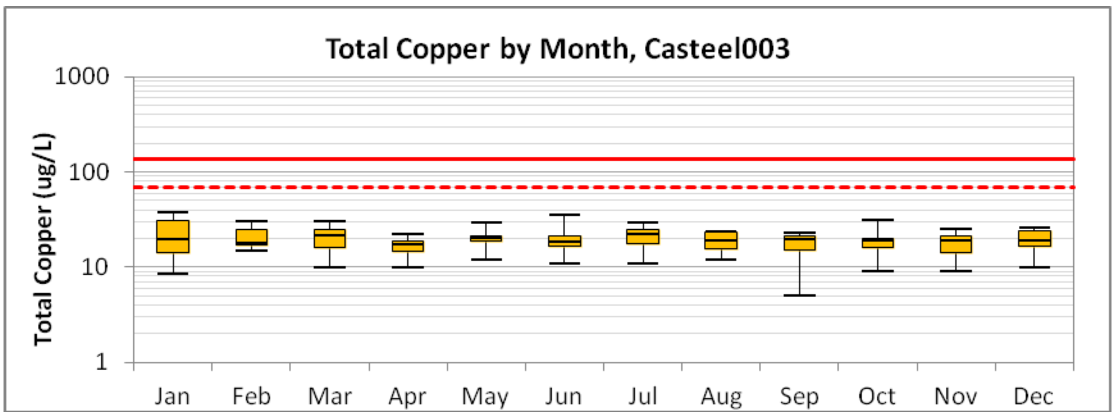


Figure 3-19. Monthly Box Plots for Total Copper at Casteel003.

Box plots for total lead are presented in Figure 3-19 and Figure 3-20 for outfalls 001 and 003, respectively. Although the data appear to vary somewhat more from month to month than some other metals, there does not appear to be a strong seasonal variation at either outfall.

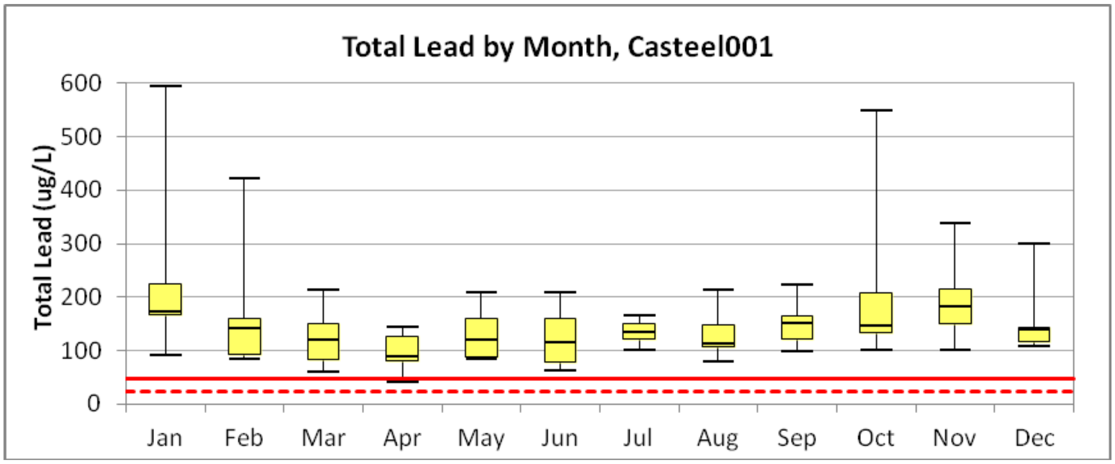


Figure 3-20. Monthly Box Plots for Total Lead at Casteel001.

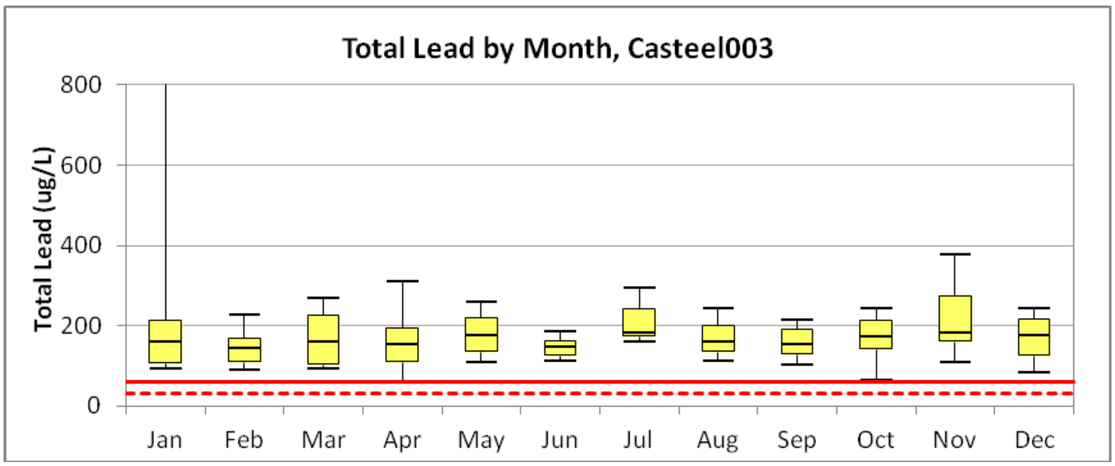


Figure 3-21. Monthly Box Plots for Total Lead at Casteel003.

Figures 3-21 and 3-22 present monthly box plots for total zinc at outfalls 001 and 003, respectively. As with other metals, these data do not suggest a pattern of seasonal variation.

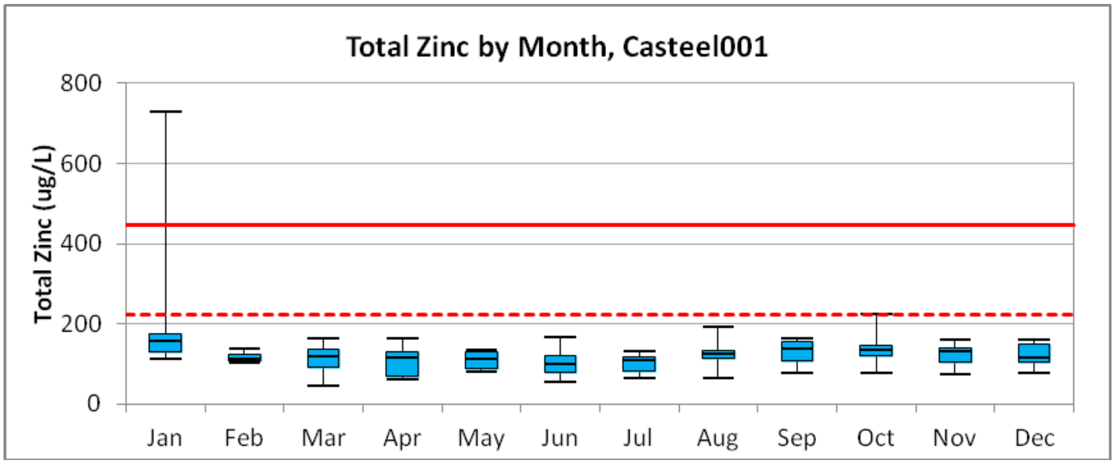


Figure 3-22. Monthly Box Plots for Total Zinc at Casteel001.

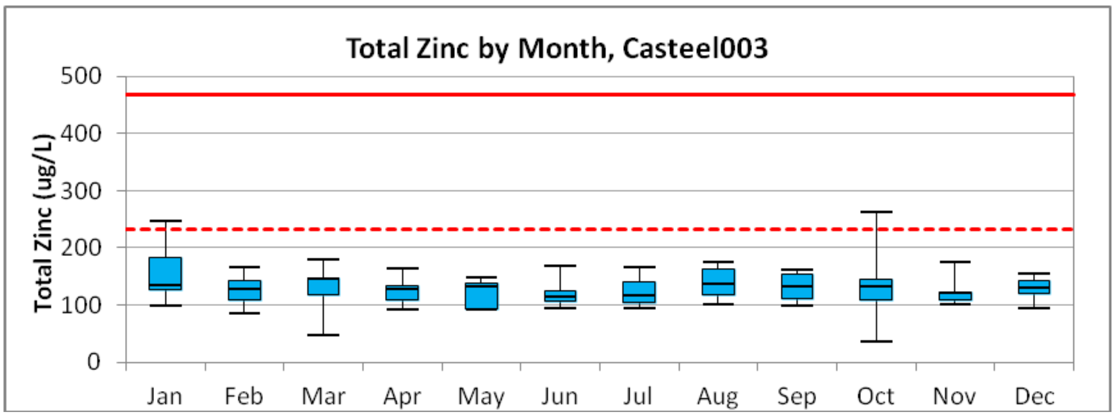


Figure 3-23. Monthly Box Plots for Total Zinc at Casteel003.

3.2.3 Comparison of Dissolved Metals to Total Metals

In evaluating the potential for attainment of future final MSOP limits and potential measures to control metals in effluent, it is important to understand the relationship between dissolved and total metals. For purposes of this SWMP, this was accomplished by adding dissolved metals results to the probability plots presented in Section 3.2.1.b. This approach allows a visual qualitative determination of whether attainment is significantly influenced by metals in the dissolved phase, as opposed to metals associated with suspended solids.

Figure 3-23 shows probability plots for total and dissolved cadmium for outfalls 001 and 003. The distributions for dissolved and total cadmium are similar, but dissolved cadmium shows a significantly higher probability of meeting both future final daily and future final monthly limits than total cadmium. This indicates that control of both solid and dissolved phase cadmium is important in attaining future final MSOP limits at Casteel.

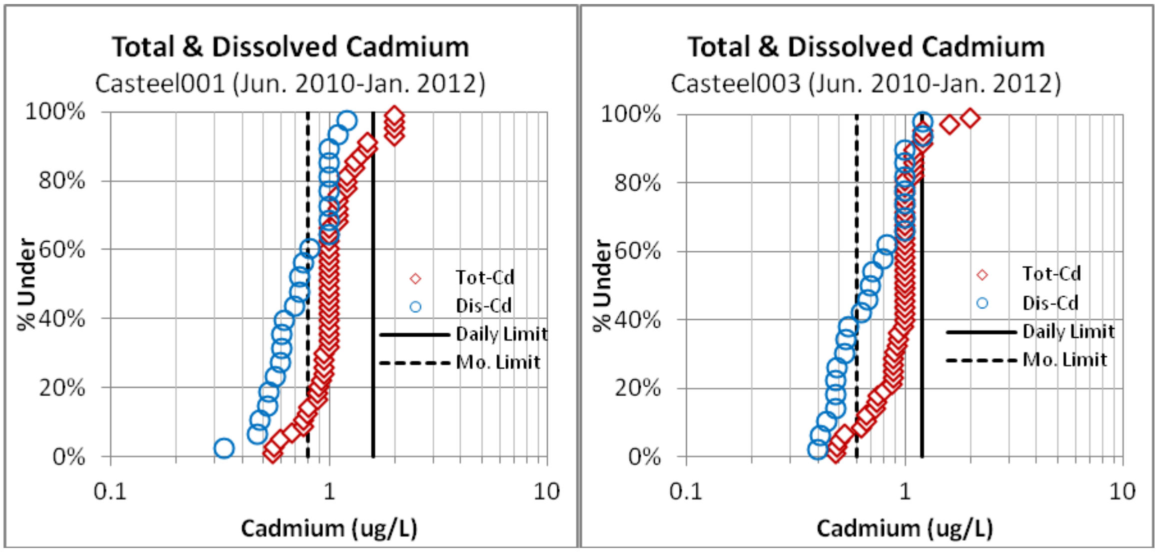


Figure 3-24. Probability Plots for Total and Dissolved Cadmium, Casteel001/003.

Probability plots for total and dissolved copper for outfalls 001 and 003 are shown in Figure 3-24.

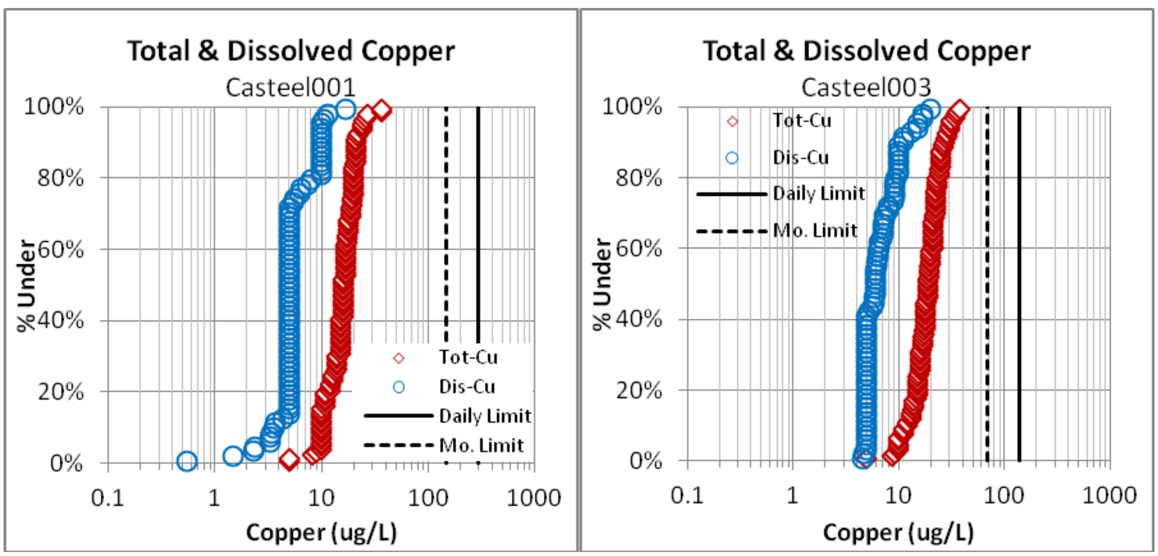


Figure 3-25. Probability Plots for Total and Dissolved Copper, Casteel001/003.

For both outfalls, the distribution for dissolved copper is fairly well separated from the total copper distribution, suggesting that dissolved copper is less a factor in attaining future final limits than total copper. However, for both outfalls, the distributions fall well below the future final MSOP limits, which indicates copper is not a significant issue at Casteel.

Figure 3-25 shows the probability plots for total and dissolved lead for outfall 001 and outfall 003.

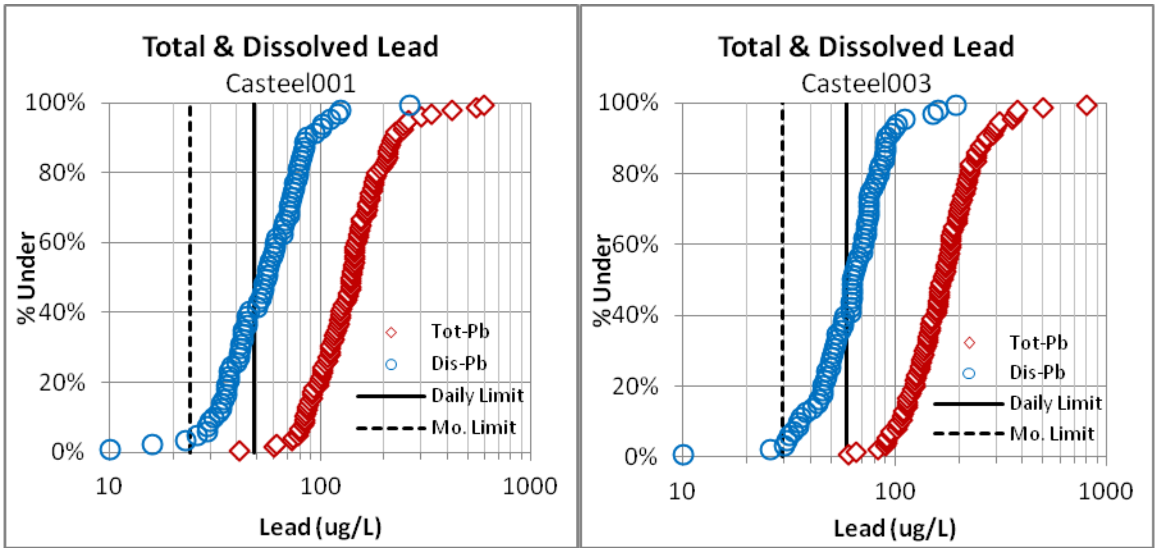


Figure 3-26. Probability Plots for Total and Dissolved Lead, Casteel001/003.

For both outfalls, the distribution for dissolved lead is very well separated from the total lead distribution, suggesting that dissolved lead is less a factor in attaining future limits than total lead. However, for both outfalls, the distributions fall well above the future final monthly average MSOP limit. Also, the distribution of dissolved lead in both outfalls show that the probability of dissolved lead alone attaining the future final daily average limits is only about 40%. These observations indicate that control of both total and dissolved lead will likely be necessary to attain future final MSOP limits at Casteel.

Probability plots for total and dissolved zinc for outfalls 001 and 003 are shown in Figure 3-26. The distributions for dissolved and total zinc are very similar and both fall below the future final MSOP limits nearly all the time. These results indicate that zinc is not a significant concern for the Casteel outfalls.

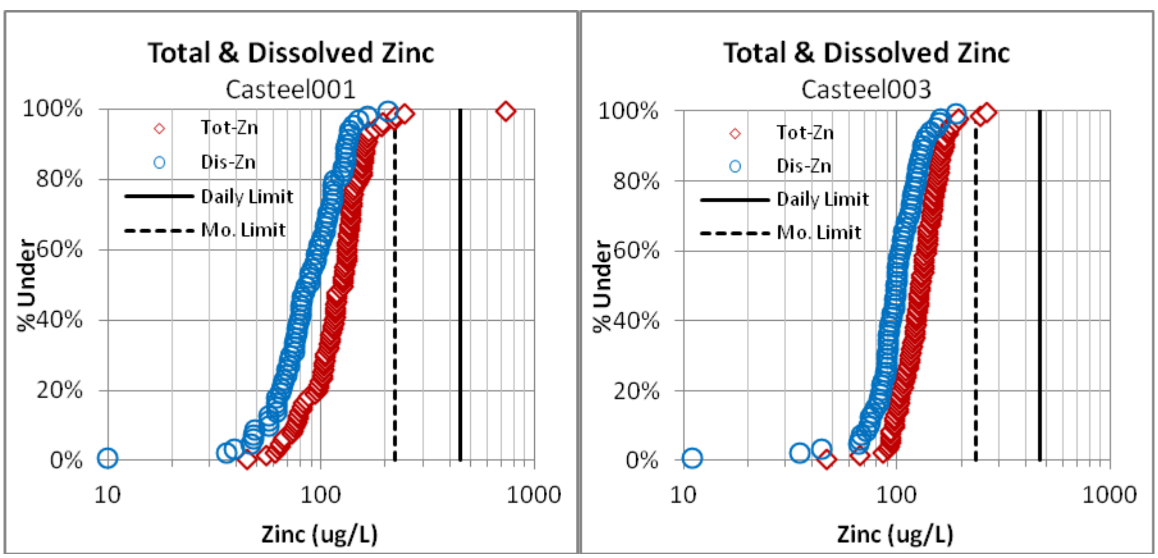


Figure 3-27. Probability Plots for Total and Dissolved Zinc, Casteel001/003.

3.3 SOURCES OF METALS LOADING TO OUTFALLS

As described previously in section 2.1, there are three major sources of flow to the mine water basin outfalls at the Casteel facility:

- Mine Water
- Storm Water
- Truck Wash Water

Each of these flows also carries a metals load to the basins. These loads, as well as their relative importance to effluent quality, are discussed below.

3.3.1 Mine Water

Sixteen samples of influent mine water were collected at each mine water basin for use in characterizing mine water for this evaluation (sample locations MW001 and MW003). The data from these samples represent the mine water quality coming from the main mine water sump in Casteel Mine. At the time of this SWMP, no data are available for the mine water coming from the V10 sump into mine water basin 003, but sampling of the V10 influent began the week of April 23, 2012. Those data will be evaluated and discussed in the next version of this SWMP. This line is now being sampled and the mine water from the V10 sump will be compared to the mine water from the main Casteel sump in the next update to this plan.

Because the influent mine water to both basins originates at the mine water box, the quality of the influent to each basin is expected to be similar. Box plots of the data from MW001 and MW003 are presented in Figure 3-27 through Figure 3-30 for total cadmium, total copper, total lead and total zinc.

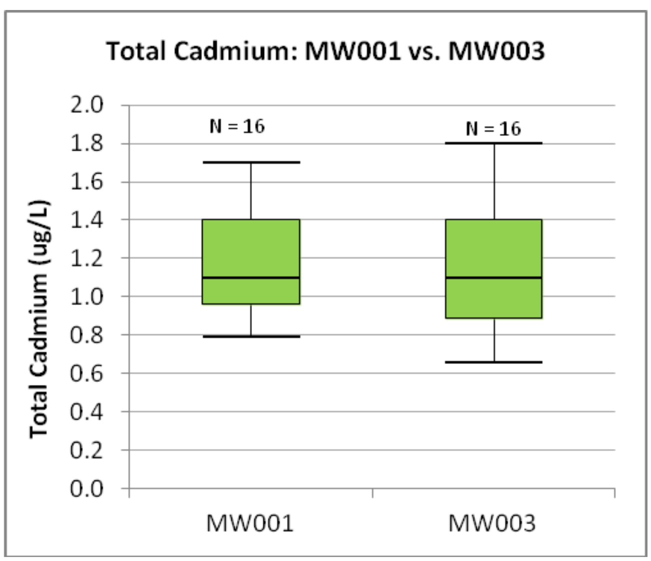


Figure 3-28. Box Plots Comparing Total Cadmium in Influent to the Casteel Mine Water Basins.

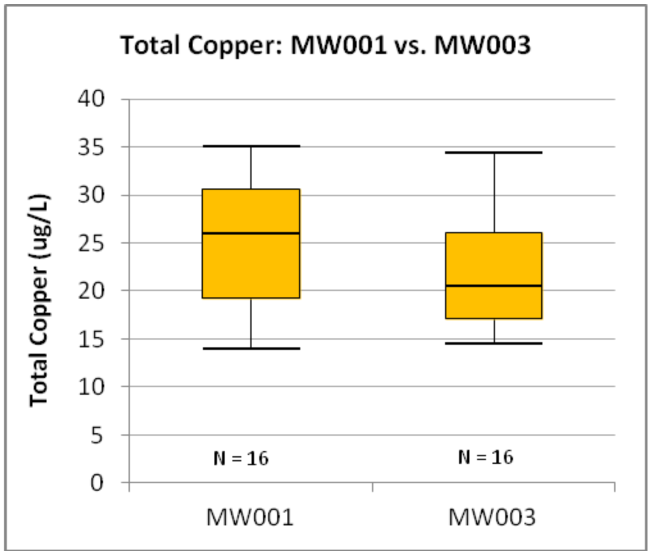


Figure 3-29. Box Plots Comparing Total Copper in Influent to the Casteel Mine Water Basins.

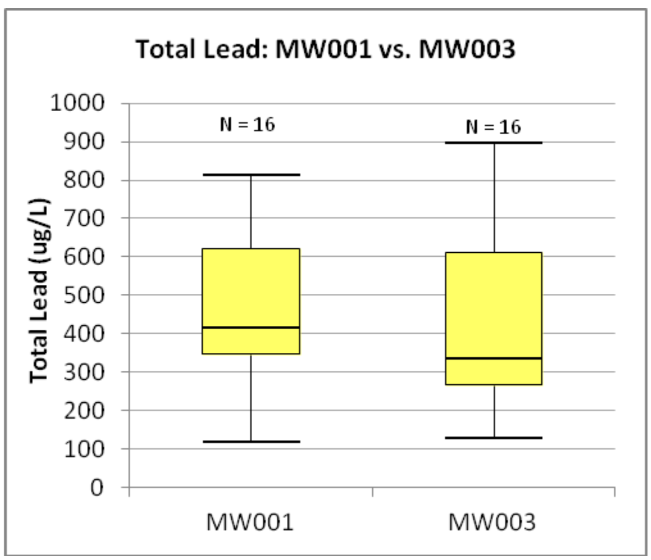


Figure 3-30. Box Plots Comparing Total Lead in Influent to the Casteel Mine Water Basins.

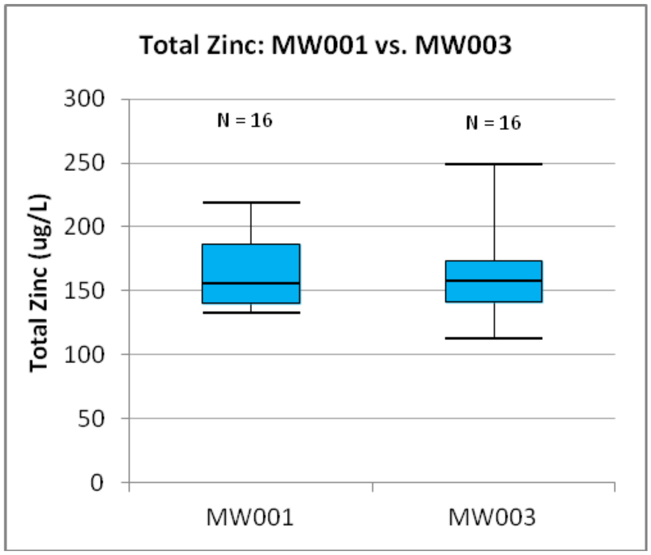


Figure 3-31. Box Plots Comparing Total Zinc in Influent to the Casteel Mine Water Basins.

Comparison of incoming mine water at both mine water basins supports the following observations:

- The range of concentrations and median values of total cadmium in influent mine water are very similar for both mine water basins.
- The range of concentrations of total copper in influent mine water is very similar for both mine water basins. The median copper concentration at MW001 is slightly higher than the median at MW003.
- The range of concentrations of total lead in influent mine water is similar for both mine water basins. The median lead concentration at MW001 is slightly higher than the median at MW003.
- The range of concentrations of total zinc in influent mine water at MW003 is slightly larger than at MW001, but the median zinc concentrations are very similar at both mine water basins.

Overall, these box plots show very little difference in influent mine water to the two mine water basins, as is expected. The average, minimum and maximum concentrations of total metals in influent mine water for the two basins are summarized in Table 3-7.

Table 3-7. Average, Minimum and Maximum Concentrations of Total Metals in Mine Water Basin Influent at Casteel.

Parameter	Units	Avg. Concentration		Min. Concentration		Max. Concentration	
		MW001	MW003	MW001	MW003	MW001	MW003
Total Cadmium	µg/L	1.2	1.1	0.8	0.7	1.7	1.8
Total Copper	µg/L	25.0	22.1	14.0	14.5	35.1	34.4
Total Lead	µg/L	460.2	431.6	120.0	129.0	815.0	897.0
Total Zinc	µg/L	163.1	163.1	133.0	113.0	219.0	249.0

Average metals loading rates to the mine water basins from mine water were calculated using the average concentrations in Table 3-7 and the average mine water flows discussed in Section 2.2. These calculated average loads can serve as a point of comparison for other potential sources of metals loading, including storm water runoff and truck wash water. The average calculated loads are presented in Table 3-8.

Table 3-8. Average Calculated Metals Loads to Mine Water Basins from Mine Water at Casteel.

Metal	Average Load to Mine Water Basins from Mine Water (kg/yr)		Combined Average Load to Mine Water Basins from Mine Water (kg/yr)
	Basin 001	Basin 003	
Cadmium	0.3	0.3	0.6
Copper	6.0	5.3	11.3
Lead	111	103	214
Zinc	39	39	78

3.3.2 Storm Water

As noted in Section 2.1.5, there is more than seven times as much storm water flow entering basin 003 and there is entering basin 001, on average. Because the drainage areas to the basins have similar surface characteristics, it is reasonable to assume they would generate similar runoff quality. And, if the quality (*i.e.*, metals concentrations) in the runoff is similar, then load should be proportional to flow and the metals load to basin 003 from storm water should be about seven times the load entering basin 001 from storm water. If storm water was a significant metals loading contributor to the mine water basins, then one would expect to see an effect at the outfall, with higher metals concentrations at outfall 003 than at outfall 001, since the mine water concentrations and loads are similar. To evaluate this, total metals at the outfalls were compared using box plots, as shown in Figure 3-31 through Figure 3-34.

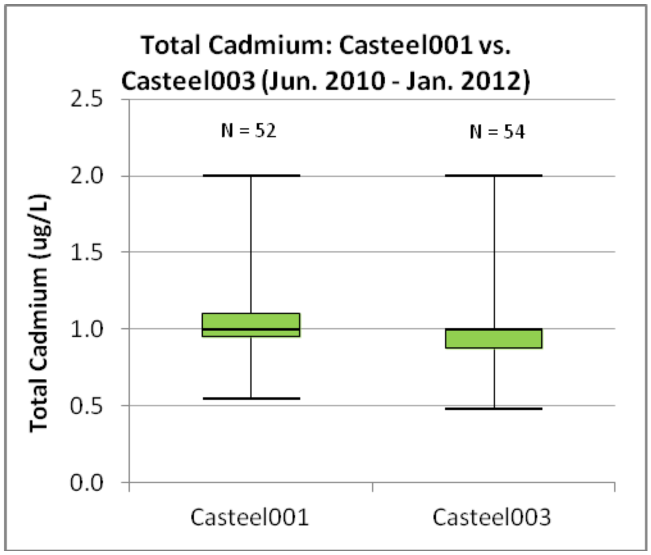


Figure 3-32. Box Plots Comparing Total Cadmium in Casteel Mine Water Basin Outfalls.

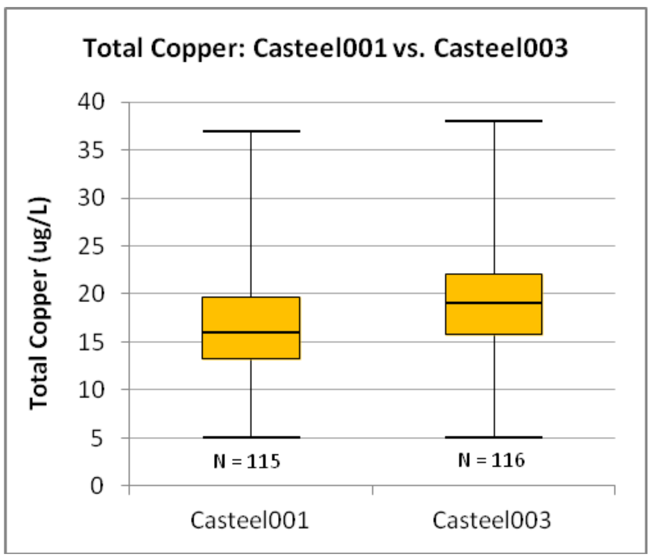


Figure 3-33. Box Plots Comparing Total Copper in Casteel Mine Water Basin Outfalls.

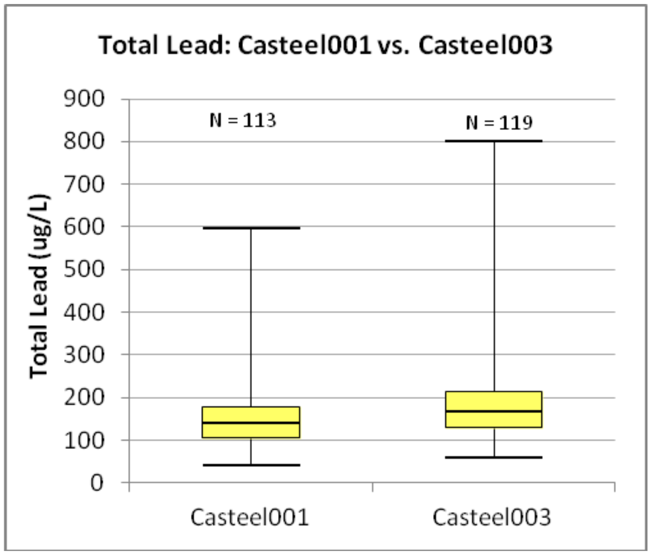


Figure 3-34. Box Plots Comparing Total Lead in Casteel Mine Water Basin Outfalls.

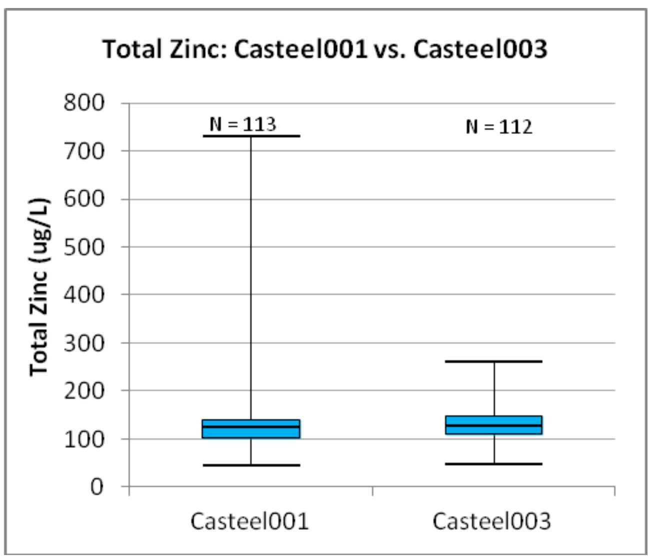


Figure 3-35. Box Plots Comparing Total Zinc in Casteel Mine Water Basin Outfalls.

Overall, these box plots show very little difference in total metals between the two mine water outfalls, as is expected. Although there is a significant difference in storm water flows to the two mine water basins, total average storm water flow is a small fraction of the total mine water flow; the ratio of total mine water flow at Casteel to storm water flows is more than 150:1. Therefore, storm water runoff would have to have relatively high metals concentrations, compared to mine water, for there to be a discernible impact on outfall quality.

3.3.3 Truck Wash

The influent to mine water basin 003 from the truck wash was evaluated to assess the relative impact of truck wash on water quality at mine water outfall 003. Two samples of influent to the mine water basin from the truck wash were collected in 2011 and on both occasions, the total metals concentrations were higher in the influent from the truck wash than in the mine water influent and effluent samples that were collected concurrently. These results are presented in Table 3-9 and depicted graphically in Figure 3-35.

Table 3-9. Concurrent Sampling Results for Truck Wash and Mine Water Locations.

		3/1/2011			5/18/2011		
Parameter	**Units**	**TWEFF**	**MW003**	**Casteel003**	**TWEFF**	**MW003**	**Casteel003**
Total Cadmium	µg/L	7.9	1.1	1.2	2.7	0.8	1
Total Copper	µg/L	303	20.1	25	90	19	16
Total Lead	µg/L	4960	136	270	2206	129	110
Total Zinc	µg/L	672	146	148	301	151	139
Tot. Susp. Solids	mg/L	41	5	5	51	6	3

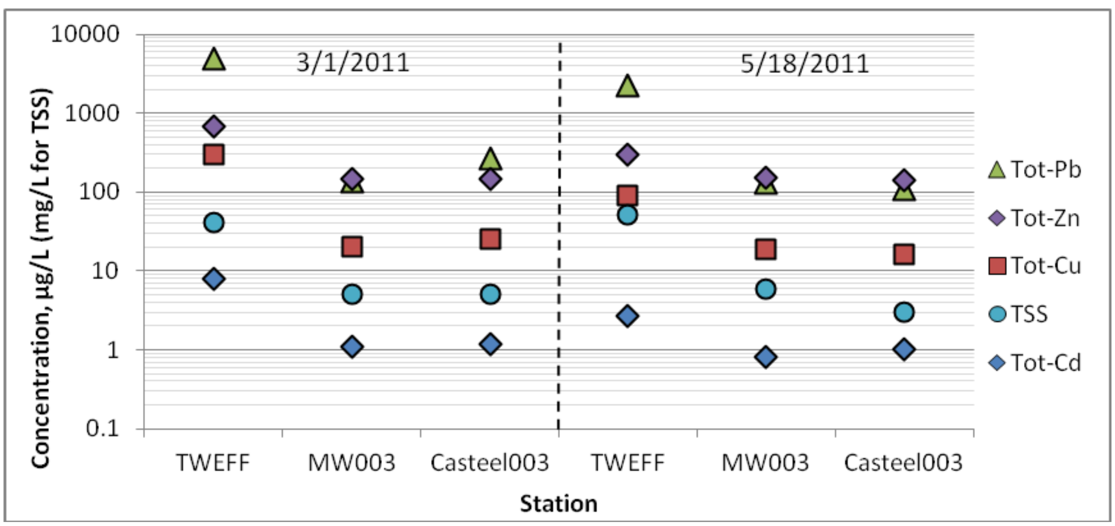


Figure 3-36. Sampling Results for Total Metals and Solids, Truck Wash and Mine Water Locations.

The data for the influent to mine water basin 003 from the truck wash can be used, in conjunction with the flow estimates developed in Section 2.1.6, to calculate metals loading estimates for the Casteel truck wash. These estimates are presented in Table 3-10, along with the estimated loads to basin 003 from mine water, for comparison. Comparing the second and third columns of this table, it is apparent that mine water contributes a significantly higher load of metals than the truck wash.

Table 3-10. Average Metals Loads to Mine Water Basin 003 from Truck Wash at Casteel.

Metal	Average Load to Mine Water Basin 003 from Truck Wash (kg/yr)	Average Load to Mine Water Basin 003 from Mine Water (kg/yr)
Cadmium	0.03	0.3
Copper	1.2	5.3
Lead	22	103
Zinc	3	39

It should also be noted that the results shown in Figure 3-35 indicate that effluent from the mine water basins closely resembles incoming mine water as far as total metals concentrations, whereas the influent from the truck wash has significantly higher total metals than either the mine water or the basin effluent. This is a further indication that the truck wash does not significantly impact water quality at the outfall.

3.4 SOURCE ASSESSMENT SUMMARY

There are three major sources of target metals to the mine water basins at Casteel and, subsequently, to surface waters via the mine water basin outfalls: mine water, storm water runoff, and truck wash water. A summary of each of these sources, based on the data evaluations presented in the preceding sections, is presented below.

- Based on the comparison of historical metals concentrations at the Casteel mine water basin outfalls to the future final MSOP limits, total cadmium and total lead have far greater potential to exceed the future final MSOP limits than total copper or total zinc. Total cadmium and total lead are, therefore, of far greater priority in surface water management planning at Casteel.
- Mine water is the largest flow and the largest source of metals loading to the mine water basins.
- Storm water flows are so small compared to mine water flows that it is unlikely they have a significant effect on water quality in the mine water basins. In addition, the fact that there is little difference in water quality between the two outfalls supports the conclusion that storm water runoff has little impact of mine water basin effluent quality.
- The available data indicate that truck wash effluent does not significantly impact water quality at the outfall of mine water basin 003.

These observations lead to the conclusion that actions to reduce metals concentrations in the influent to the mine water basin from the truck wash or storm water runoff to the mine water basins will have little effect on basin effluent quality.

This page is blank to facilitate double sided printing.

4. FATE AND TRANSPORT EVALUATION

To understand and evaluate potential control measures for reducing metals concentrations at the Casteel facility permitted outfalls, it is necessary to define the major fate and transport processes that affect metals in water before it reaches the outfalls. This section of the SWMP identifies the significant fate and transport processes affecting water quality at the outfalls and provides an evaluation of those processes to support identification of control measures.

4.1 IDENTIFICATION OF POTENTIAL FATE AND TRANSPORT PROCESSES AFFECTING OUTFALL WATER QUALITY AT CASTEEL

As stated in Section 3 of this plan, mine water is the major source of metals loading to outfalls 001 and 003 and loading from other sources (storm water runoff and truck wash water) appears to have little or no effect on effluent quality from the mine water basins. Therefore, the goal of meeting future final MSOP limits at the Casteel facility must be met by reducing metals concentrations in mine water. At Casteel, mine water is pumped to the surface and discharged directly from pipes into the mine water basins. This being the case, the fate and transport processes that affect metals in mine water before discharge are the processes within the mine water basins themselves, including the following:

- Solids settling – Metals already complexed with suspended solids can settle out of suspension. This process would result in a decrease in metals concentration between the mine water influent and the outfall, accompanied by a decrease in TSS between these locations.
- Solids resuspension – This is the opposite of settling; solids on the bed of the basin are resuspended into the water column by hydrodynamic or wind-driven energy.
- Adsorption to solids – Metals can be adsorbed to solids on the bed of the basins or to organic (algal) solids in the water column. This would result in a decrease in dissolved metals concentrations between the mine water influent and the outfall.
- Dilution – Inflows of water with metals concentrations that are significantly lower than the metals concentrations in mine water can result in a more dilute solution at the outfall. This process would result in a decrease in metals concentration between the mine water influent and the outfall and would be accompanied by a high volume of inflowing water with metals concentrations significantly lower than the mine water.

Of these processes, the first three are theoretically possible for the Casteel mine water basins. Dilution is not a likely process for the Casteel mine water basins because there is no inflow of sufficiently high flow rate and low concentration that would result in significant dilution of the mine water. The other processes identified above are evaluated in the following section.

4.2 EVALUATION OF POTENTIAL FATE AND TRANSPORT PROCESSES AFFECTING METALS AT CASTEEL MINE WATER OUTFALLS

The potential fate and transport processes for metals in the Casteel mine water basins, identified in Section 4.1, are evaluated below.

4.2.1 Solids Settling in Mine Water Basins

Settling of suspended solids in the mine water basins will reduce TSS and potentially reduce total metals concentrations at the outfall if significant metals are associated with the TSS. To evaluate whether this process is currently occurring in the Casteel mine water basins, box plots were constructed to evaluate whether total metals and solids concentrations appear to decrease within the mine water basins between their inlet and outlet. Stations MW001 and MW003 represent mine water entering basins 001 and 003, respectively. Stations Casteel001 and Casteel003 are the outfalls of the mine water basins. MSOP effluent limits are included in the plots to facilitate comparison of effluent concentrations with applicable effluent standards.

Box plots for total cadmium[8], copper, lead, zinc and TSS at the mine water basin inlets and outlets are presented in Figure 4-1 through Figure 4-5.

[8] As discussed previously, the total cadmium plots use data measured at the four target locations between June 2010 and January 2012. This time period was selected because prior to June 2010, detection limits of both 5 µg/L and 10 µg/L were used for cadmium. Consequently, most samples were non-detect and would not add value in comparing the data to MSOP effluent limits (all effluent limits are below 5 µg/L).

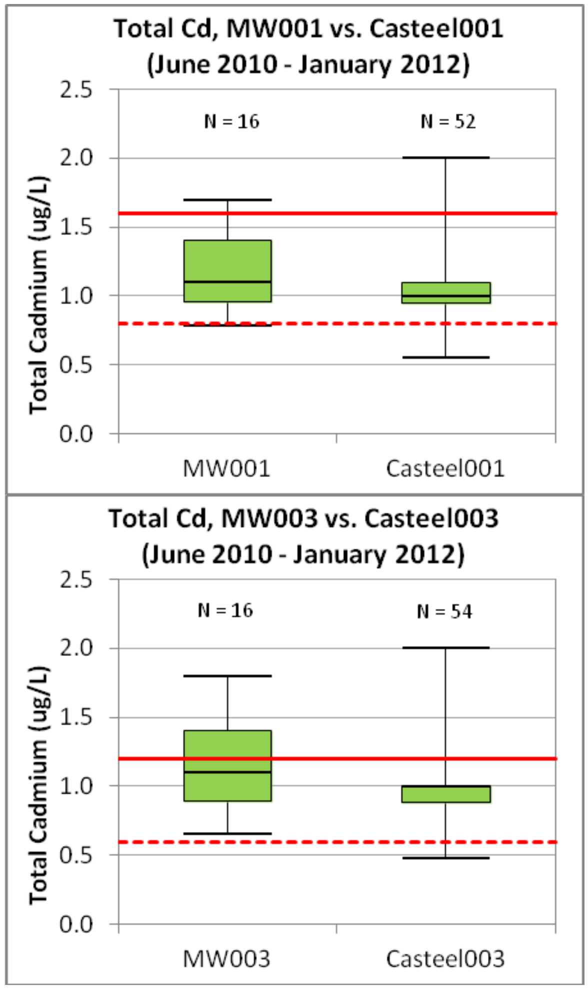


Figure 4-1. Comparison of Total Cadmium Concentration Entering and Leaving Casteel Mine Water Basins

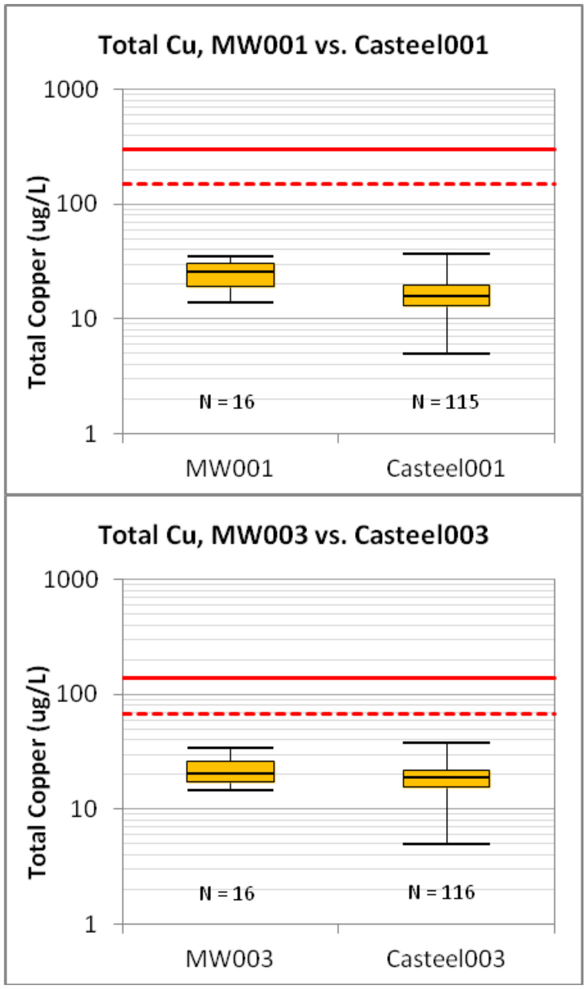


Figure 4-2. Comparison of Total Copper Concentration Entering and Leaving Casteel Mine Water Basins

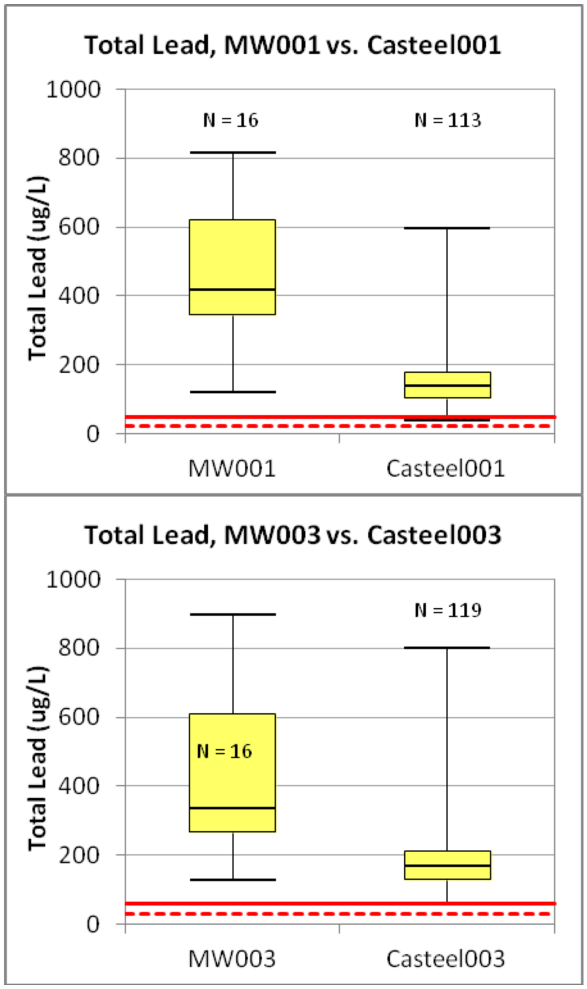


Figure 4-3. Comparison of Total Lead Concentration Entering and Leaving Casteel Mine Water Basins

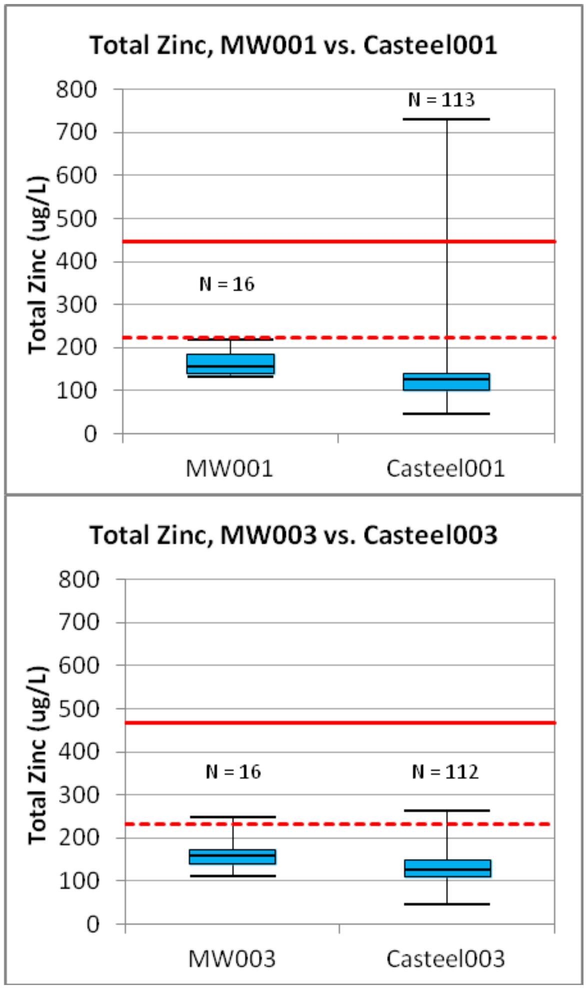


Figure 4-4. Comparison of Total Zinc Concentration Entering and Leaving Casteel Mine Water Basins

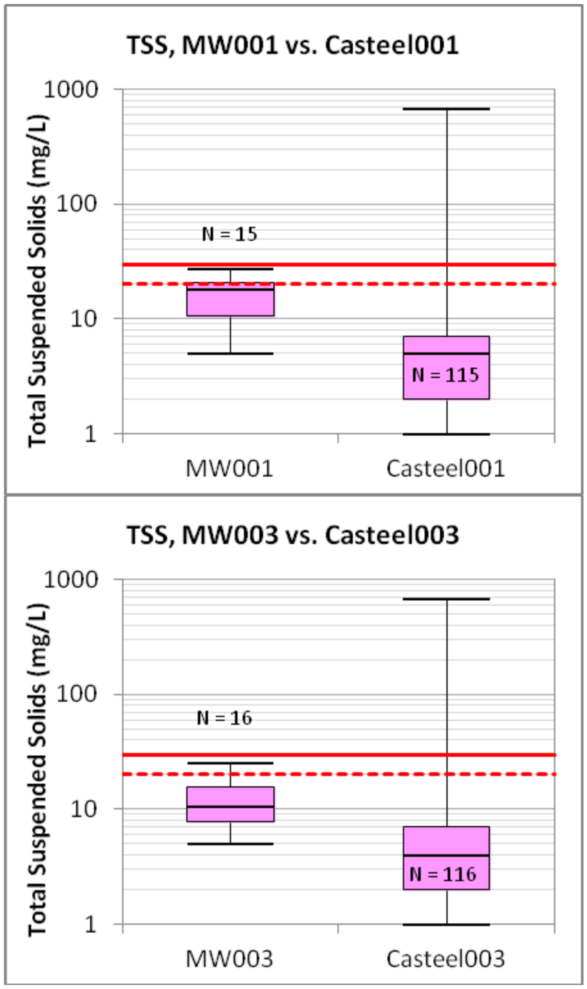


Figure 4-5. Comparison of TSS Concentration Entering and Leaving Casteel Mine Water Basins

Table 4-1 summarizes the average concentrations calculated for each parameter at MW001 and Casteel001, as well as the decrease in concentration based on the change in average concentration. Table 4-2 summarizes the same information for MW003 and Casteel003.

Table 4-1. Change in Average Total Metals and TSS Concentrations Between Influent and Effluent in Casteel Mine Water Basin 001.

Parameter	Units	Average Concentration		Decrease in Concentration	Percent Decrease
		MW001	Casteel001		
Total Cadmium	µg/L	1.2	1.1	0.1	7%
Total Copper	µg/L	25.0	16.4	8.6	34%
Total Lead	µg/L	460.2	153.8	306.4	67%
Total Zinc	µg/L	163.1	126.8	36.3	22%
Total Suspended Solids	mg/L	16.2	10.7	5.5	34%

Table 4-2. Change in Average Total Metals and TSS Concentrations Between Influent and Effluent in Casteel Mine Water Basin 003.

Parameter	Units	Average Concentration		Decrease in Concentration	Percent Decrease
		MW003	Casteel003		
Total Cadmium	µg/L	1.1	1.0	0.2	15%
Total Copper	µg/L	22.1	19.4	2.7	12%
Total Lead	µg/L	431.6	184.5	247.1	57%
Total Zinc	µg/L	163.1	131.6	31.4	19%
Total Suspended Solids	mg/L	12.8	11.5	1.4	11%

Comparing the changes in average concentrations of target parameters across the Casteel mine water basins, the following observations can be made:

- Average influent concentrations of all parameters are very similar between the two basins, which is expected given that the mine water originates at the same place.
- Total lead shows the largest reduction in average concentration across both mine water basins: 67% in basin 001 and 57% in basin 003. This may be because lead tends to be more strongly correlated with TSS or because total lead concentrations are higher than other parameters in the Casteel mine water to begin with.
- Total cadmium shows the lowest reduction in basin 001 (7%), but not in basin 003. Lower reduction rates for cadmium are expected because the incoming concentrations are very low to begin with.
- The decrease in average TSS for basins 001 and 003 was 34% and 11%, respectively, but these removal rates are significantly lower than the removal rates for total lead.

If most of the lead is associated with TSS in the mine water, it is expected that the removal rates for these two parameters would be similar. One possible explanation for the discrepancy is that sediments are being resuspended by turbulence in the basins. This process is addressed in the following section.

4.2.2 Solids Resuspension in Mine Water Basins

The surfaces of the Casteel mine water basins are open to the atmosphere and therefore subject to turbulence caused by wind. In addition, mine water is pumped into the basins at a relatively high rate (about 1,700 gpm into each basin) from pipes at or near the water surface. This flow, discharged from a one-foot diameter pipe, enters the basins at a velocity of approximately five feet per second, which is more than adequate to resuspended the unconsolidated sediment on the bottom of the basins.

Although the data presented in Section 4.2.1 show that the concentrations of total metals and TSS decrease on average, the maximum concentration of TSS measured at each outfall was actually greater than the maximum concentration measured at the inlet by more than an order of magnitude. This may be due to disturbance during sampling, but it may also indicate resuspension of sediments is occurring in the basins. While the elevation of TSS by resuspension does not appear to completely negate the reduction of total metals in the basins, it may lower reduction rates.

4.2.3 Adsorption to Soil Solids in Mine Water Basins

Adsorption of dissolved metals to solids in the Casteel mine water basins is another process by which reductions in metals concentrations could occur within the basins. One possibility is that dissolved metals might become adsorbed to solids on the bed of the basins. This is unlikely to occur in the mine water basins as it would require quiescent conditions and long contact times. A second possibility is that algal growth during the warm season creates organic solids in the water column to which dissolved metals become adsorbed. These organic solids then settle and the result is a reduction in dissolved metals between the inlet and outfall.

If this process is a significant one within the mine water basins, a decrease in dissolved metals concentrations between the mine water inlet and the outfall in each basin would be expected. Box plots comparing the dissolved metals concentrations between the inlet and outfall of each basin are presented in Figures 4-6 through 4-9 for dissolved cadmium, copper, lead and zinc.

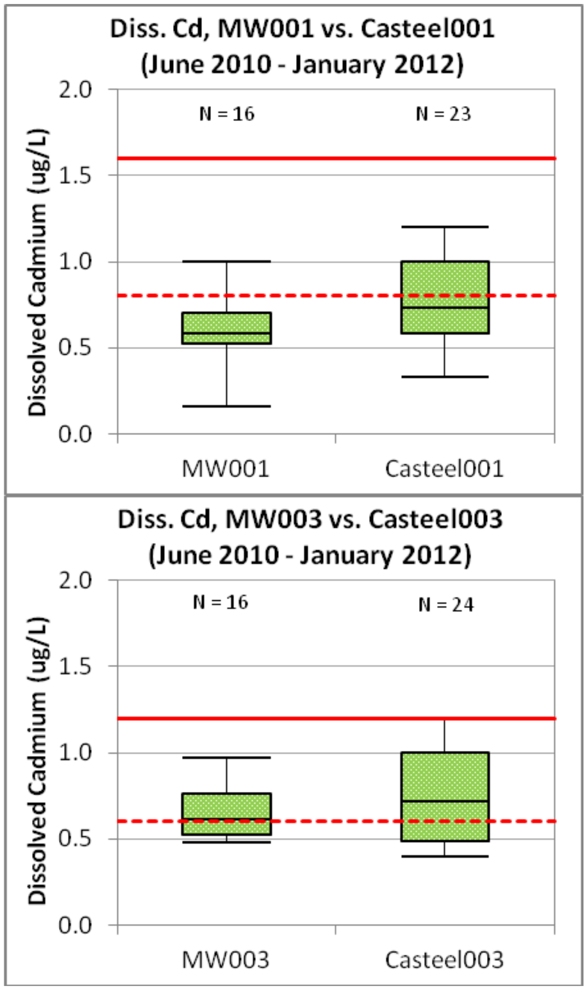


Figure 4-6. Comparison of Dissolved Cadmium Concentration Entering and Leaving Casteel Mine Water Basins

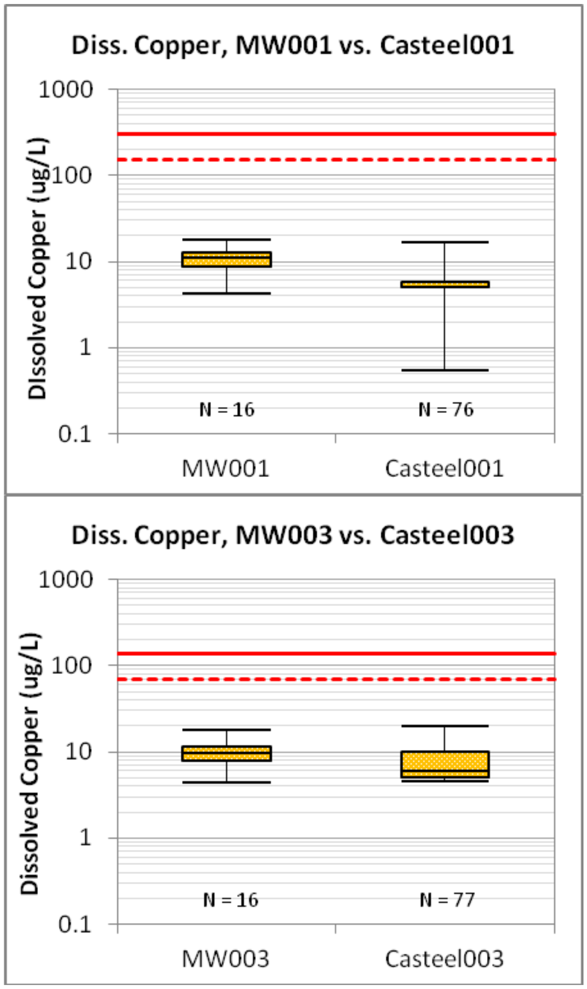


Figure 4-7. Comparison of Dissolved Copper Concentration Entering and Leaving Casteel Mine Water Basins

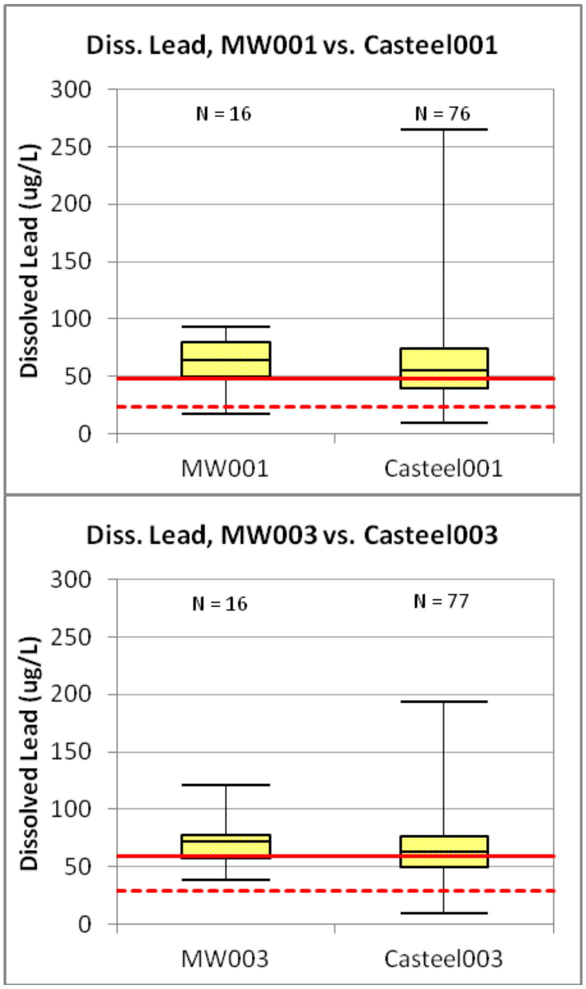


Figure 4-8. Comparison of Dissolved Lead Concentration Entering and Leaving Casteel Mine Water Basins

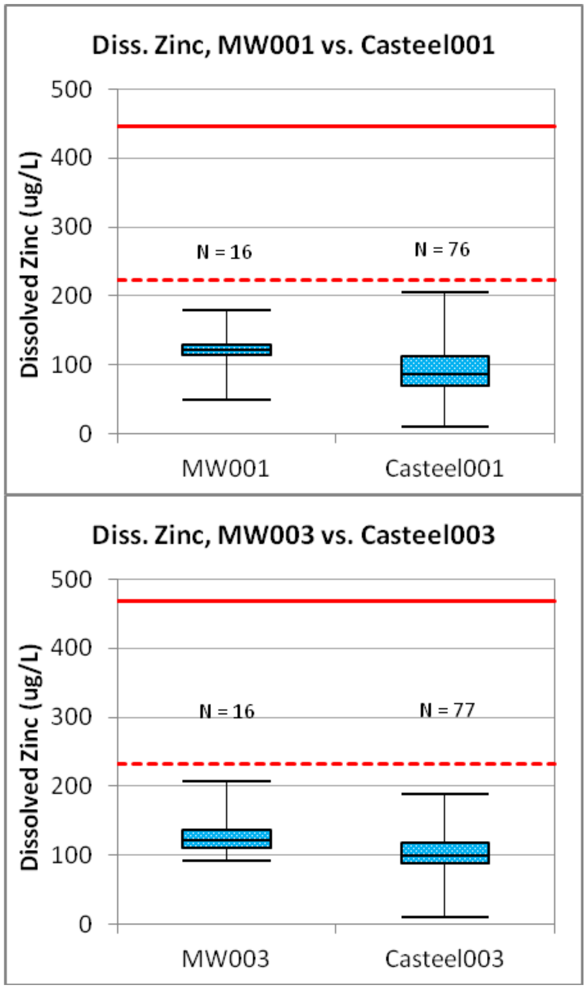


Figure 4-9. Comparison of Dissolved Zinc Concentration Entering and Leaving Casteel Mine Water Basins

Based on the comparison of dissolved metals between the inlet and outfalls of the Casteel mine water basins, it does not appear that any of the dissolved metals exhibit a significant decrease in the Casteel mine water basins. This observation indicates that adsorption to solids is not a significant fate process affecting metals concentrations in the Casteel mine water basin outfalls.

4.3 FATE AND TRANSPORT PROCESS SUMMARY FOR METALS IN CASTEEL MINE WATER BASINS

The preceding analysis and discussion can be summarized by the following findings:

- Settling of TSS appears to be occurring in the Casteel mine water basins and results in a net decrease of TSS between the inlets and outfalls, on average. This process is also likely responsible for the net decrease in total lead between the inlets and outfalls of the basins. However, the average percent decrease in TSS is less than the average percent decrease in total lead.
- The fact that decreases in average TSS are significantly less than decreases in average total lead suggests that resuspension of settled solids may be

occurring in the basins. This is supported by the fact that the maximum measured concentrations of TSS at the outfalls are higher than the maximum measured TSS concentrations at the inlets.

- Comparison of dissolved metals between the inlet and outfalls of the Casteel mine water basins does not show a significant decrease in dissolved metals. This indicates that adsorption to solids is not a significant fate process affecting metals concentrations in the Casteel mine water basin outfalls.

These findings will inform the evaluation of potential water management measures for the Casteel facility.

5. POTENTIAL WATER MANAGEMENT MEASURES

Potential water management issues to improve effluent quality and attain future final MSOP limits are identified in this section. As stated in the Master SWMP (LimnoTech, 2011a), a hierarchy has been established as a tool for use when water management solutions are evaluated during development of Site-Specific SWMPs. The hierarchy sets priorities for the management of regulated water at Doe Run facilities and is presented in Figure 5-1.

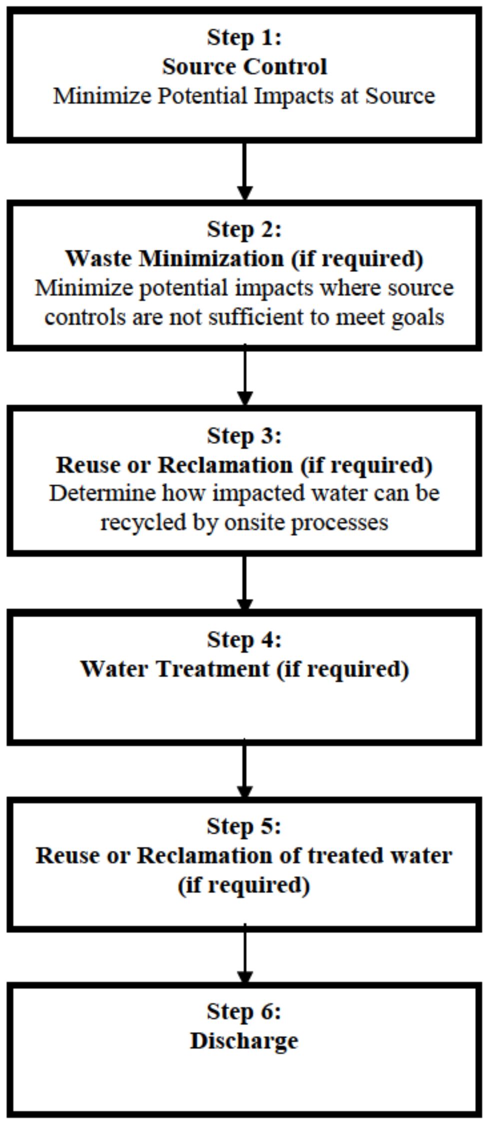


Figure 5-1. Hierarchy of Water Management Priorities

The water management hierarchy shown in Figure 5-1 establishes source control or pollution prevention through the implementation of Best Management Practices

(BMPs) as a top priority. BMPs can also support waste minimization. The hierarchy lists water treatment but in addition to treatment, the Master SWMP also states that alternative discharge practices will be evaluated. Based on this information from the Master SWMP, the identification of potential water management measures is organized as follows:

- Best management practices (source control)
- Waste minimization
- Water reuse or reclamation
- Water treatment
- Alternative discharge practices

Each of these categories of potential water management measures is discussed below.

5.1 BEST MANAGEMENT PRACTICES

The water management hierarchy places the highest priority on source control which, in the context of the Casteel SWMP, means either reduction of the volume of water being discharged or the concentration of metals in the effluent from the mine water basins. The major flow volume through the mine water basins is mine water, as discussed in Section 2, and the Underground Water Management Plan for Casteel Mine (LimnoTech, 2012) did not identify any significant measures to reduce mine water flows. The Casteel Underground Water Management Plan did identify several BMPs to be implemented underground to minimize the concentration of metals in mine water pumped to the surface, but the effect of implementing these measures has not yet been determined. Because mine water is discharged directly to the mine water basins, there is no opportunity for BMPs at the surface to reduce mine water concentrations of metals. Any BMPs at Casteel would be designed to reduce other sources of flow and/or metals to the basins.

There are two other sources of flow and metals to the mine water basins at Casteel, as discussed in Sections 2 and 3. These are storm water and truck wash water (basin 003 only). However, the analyses presented in Sections 2 and 3 of this plan do not indicate that either of these sources is significant enough to affect effluent quality at present. In addition, numerous best management practices and procedures are already used at Doe Run facilities as part of an overall storm water management program and are discussed in the Casteel Storm Water Pollution Prevention Plan (RMC, 2011). No additional practices to significantly reduce solids and metals loading the Casteel mine water basins were identified for this plan.

5.2 WASTE MINIMIZATION

Waste minimization generally refers to the intentional reduction of potentially polluting by-products from industrial process that could affect water quality. At the Casteel facility, the major source of metals in the effluent is the naturally occurring minerals in the Casteel mine. Therefore, no opportunities for waste minimization were identified for this SWMP.

5.3 WATER REUSE OR RECLAMATION

Water reuse or reclamation can sometimes be used to reduce the total volume of effluent, thereby reducing the loading of materials to receiving waters. At Casteel, water from basin 003 is reused for washing trucks and then reintroduced to the basin, as described in Section 2.1.6 of this plan. No other opportunities for water reclamation or reuse were identified for this SWMP.

5.4 WATER TREATMENT

Water treatment is often the last water management measure to be implemented prior to discharge. At Casteel, the mine water basins are intended to provide treatment of mine water by allowing suspended solids to settle from suspension, thereby reducing TSS and total metals prior to discharge. This existing form of treatment was evaluated to determine whether improvements can be made. In addition, other forms of treatment may be feasible for Casteel mine water. Both of these potential water treatment measures are discussed below.

5.4.1 Improvement of Mine Water Basin Effectiveness

As mentioned above, the Casteel mine water basins are intended to provide treatment of mine water by allowing settling of suspended solids. This treatment not only reduces TSS, but also reduces total metals, since total metals are typically strongly correlated with TSS in mine water at Casteel (LimnoTech, 2012). Analysis of data from the basins (Section 4.2.1) confirms that the basins are reducing both TSS and total metals on average. The data also show that the average removal rate of total metals in the mine water basins is greater than the average removal rate for TSS. It was also observed that the maximum concentration of TSS at the outfall is greater than the maximum TSS concentration measured in the mine water influent.

It is likely that wind energy and hydraulic energy from mine water inflows are causing resuspension of sediments from the bottom of the basin, as discussed in Section 4.2.2. However, if the resuspended sediments were only solids that previously entered the basins as TSS in mine water, the relationship between total metals and TSS should be consistent across each mine water basin. The correlation between TSS and total metals in the influent mine water was compared to the same correlations at the outfall for each basin. These correlations are shown graphically in Figures 5-2 and 5-3 for mine water basins 001 and 003, respectively.

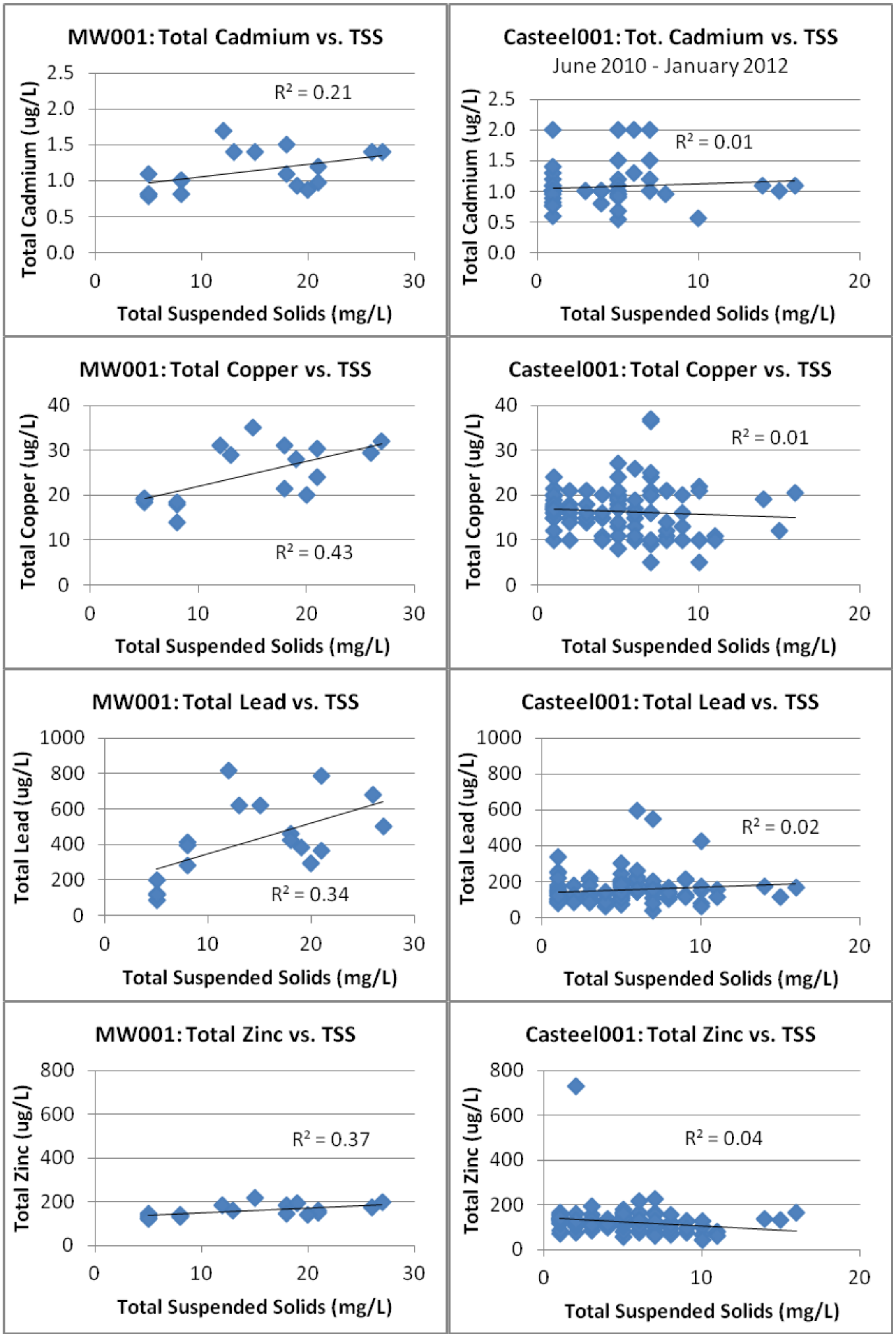


Figure 5-2. Comparison of TSS/Metals Regression in Influent and Effluent from Casteel Mine Water Basin 001

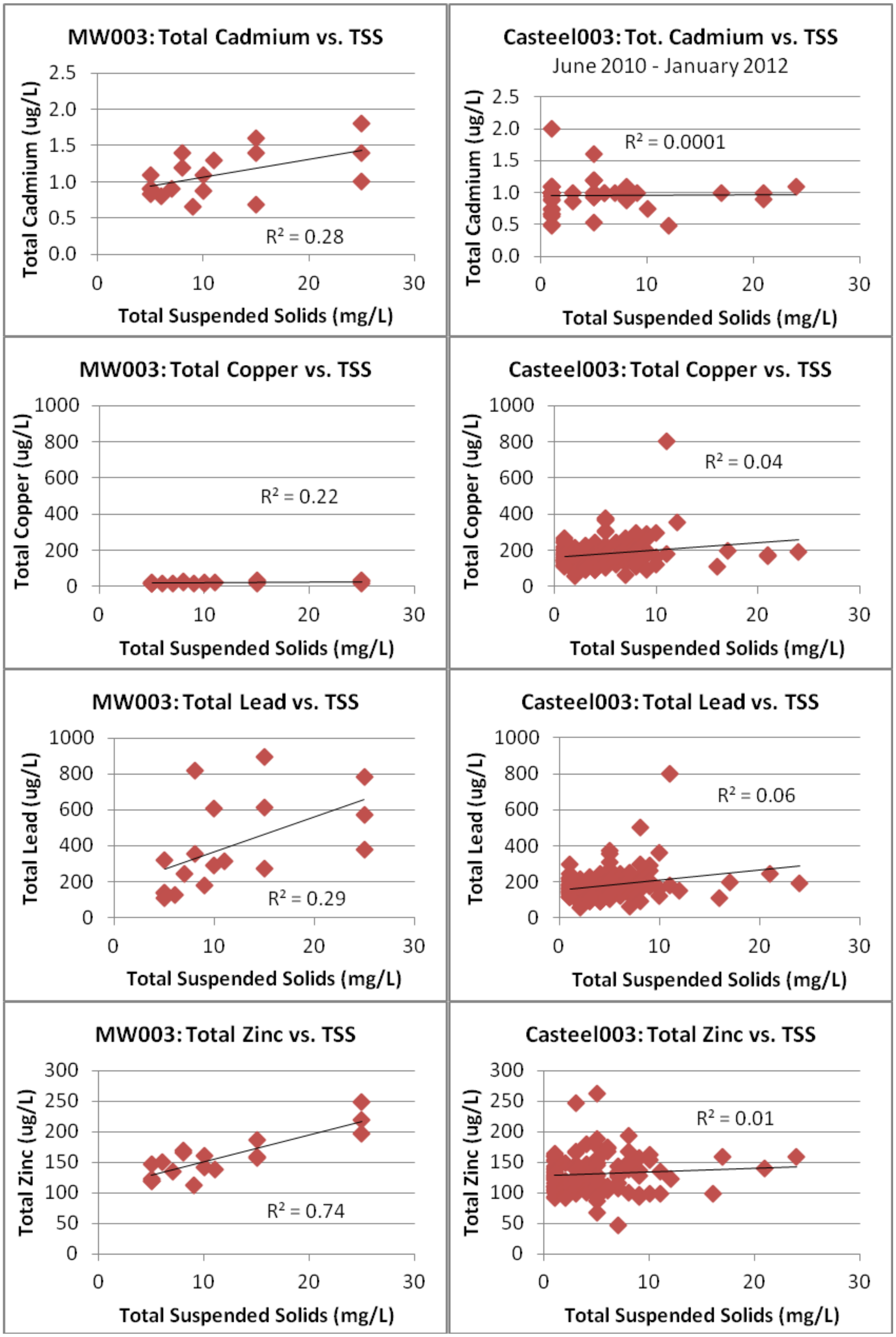

MW003: Total Cadmium vs. TSS
Total Cadmium (ug/L)
Total Suspended Solids (mg/L)
R² = 0.28
Casteel003: Tot. Cadmium vs. TSS
June 2010 - January 2012
Total Cadmium (ug/L)
Total Suspended Solids (mg/L)
R² = 0.0001
MW003: Total Copper vs. TSS
Total Copper (ug/L)
Total Suspended Solids (mg/L)
R² = 0.22
Casteel003: Total Copper vs. TSS
Total Copper (ug/L)
Total Suspended Solids (mg/L)
R² = 0.04
MW003: Total Lead vs. TSS
Total Lead (ug/L)
Total Suspended Solids (mg/L)
R² = 0.29
Casteel003: Total Lead vs. TSS
Total Lead (ug/L)
Total Suspended Solids (mg/L)
R² = 0.06
MW003: Total Zinc vs. TSS
Total Zinc (ug/L)
Total Suspended Solids (mg/L)
R² = 0.74
Casteel003: Total Zinc vs. TSS
Total Zinc (ug/L)
Total Suspended Solids (mg/L)
R² = 0.01

Figure 5-3. Comparison of TSS/Metals Regression in Influent and Effluent from Casteel Mine Water Basin 003

It is clear from these graphs and the r-squared values for each regression that there is a much stronger correlation between total metals and TSS in the incoming mine water than at the outfall, in every case. This indicates that some of the TSS at the outfall is not from mine water.

The significance of this observation is that there appears to be another source of TSS to the mine water basins other than mine water and that wind and hydraulic energy is keeping more of the TSS in suspension, reducing the settling efficiency of the basins. Possible sources of additional solids include:

- Native soil on the bed of the basins
- TSS transported by storm water runoff
- Organic solids created by algal growth in the basins

There are not enough data to evaluate the relative contribution of these non-mine water TSS sources to the basins and it is likely all three are factors. The key question is whether the settling efficiency of the mine water basins can be improved. There are two ways this might be accomplished:

- Modify the mine water inlets to the basins to provide energy dissipation for the influent mine water flows. One example of this might be the construction of a riprap channel at the head of the basin.
- Increase the flow length within the basin to prevent short-circuiting and improve hydraulic residence time. This could be accomplished by installing internal baffles.

Both of these alternatives would require additional engineering evaluation. However, Doe Run is currently considering other options that may make basin modification unnecessary, as described below, therefore basin modification is not planned at this time.

5.4.2 Enhanced Mine Water Treatment

Doe Run has recently started a series of engineering studies to evaluate mine water treatment, including the following:

- In 2011, Doe Run commissioned a bench-scale investigation of coagulation/flocculation to treat metals in mine water (Barr, 2011). This study concluded that chemical precipitation could potentially reduce metals in mine water to meet future final MSOP limits and recommended a pilot study to further verify treatment effectiveness.
- Also in 2011, Doe Run conducted pilot studies of biotreatment at the Sweetwater, Viburnum 29, and Buick facilities (RMC, 2012). The biotreatment technology tested was conceptually the same as is currently in place at Doe Run's West Fork facility. The results showed that biotreatment can also achieve low concentrations of target metals in mine water effluent.

- Doe Run has recently contracted for two pilot studies to further evaluate chemical precipitation for achieving future final MSOP limits. These tests are designed to verify the effectiveness of the technology and provide the basis for confident engineering design and cost estimation. It is expected that the pilot tests will be completed by October 2012.

Upon completion of the pilot tests that are currently underway, Doe Run will evaluate all information developed as a result of the recent studies, determine the most effective and cost-effective treatment technology for mine water, and compare the feasibility of a new mine water treatment plant at Casteel to the effectiveness and cost-effectiveness of the alternate discharge practice described in the following section.

5.5 ALTERNATIVE DISCHARGE PRACTICES

In addition to the option of constructing new on-site mine water treatment at Casteel, Doe Run is currently evaluating an alternative discharge practice for the Casteel facility. Consolidating multiple discharges to a single location and constructing and operating a single treatment facility may be more cost-effective than constructing and operating treatment facilities at each existing discharge location. In the case of the Casteel facility, an evaluation is being conducted to assess transferring the Casteel mine water through a combination of pipes and open channels to the New Viburnum tailings impoundment. The concept is shown in Figure 5-4.

Existing pumps in the New Viburnum tailings impoundment transfer water to the Old Viburnum tailings impoundment for eventual discharge to Indian Creek through Outfall #002 included in the Viburnum Operations MSOP (MO-0000086). A treatment facility is being evaluated that would handle existing discharges through Viburnum Operations Outfall #002. A larger facility is also being evaluated at Viburnum Operations Outfall #002 which would handle the additional flows resulting from a transfer of the Casteel mine water. An additional potential benefit of a transfer of Casteel mine water to the New Viburnum tailings impoundment is the ability to more effectively manage water elevations in the impoundment. The steady inflow of Casteel mine water would allow for maintenance of a water surface elevation that would more consistently cover tailings beaches and reduce windblown tailings. Full evaluation of this alternative discharge practice will require:

- Evaluation of the cost-effectiveness of a centralized mine water treatment plant versus a mine water treatment plant for Casteel alone.
- Evaluation of the cost and technical feasibility of transferring mine water from the Casteel facility to the new Viburnum tailings basin.
- Evaluation of the regulatory considerations associated with transferring mine water from the Casteel facility to the new Viburnum tailings basin.

Discussions have been initiated with MDNR to identify any potential regulatory issues associated with such a transfer and discharge scenario. The results of the engineering, cost-effectiveness, and regulatory evaluations will be considered in making a final decision on the ultimate treatment and discharge scenario for the

Casteel mine water. These evaluations will be completed by January 2013 and the final plan selected by Doe Run will be described in the next version of this SWMP.

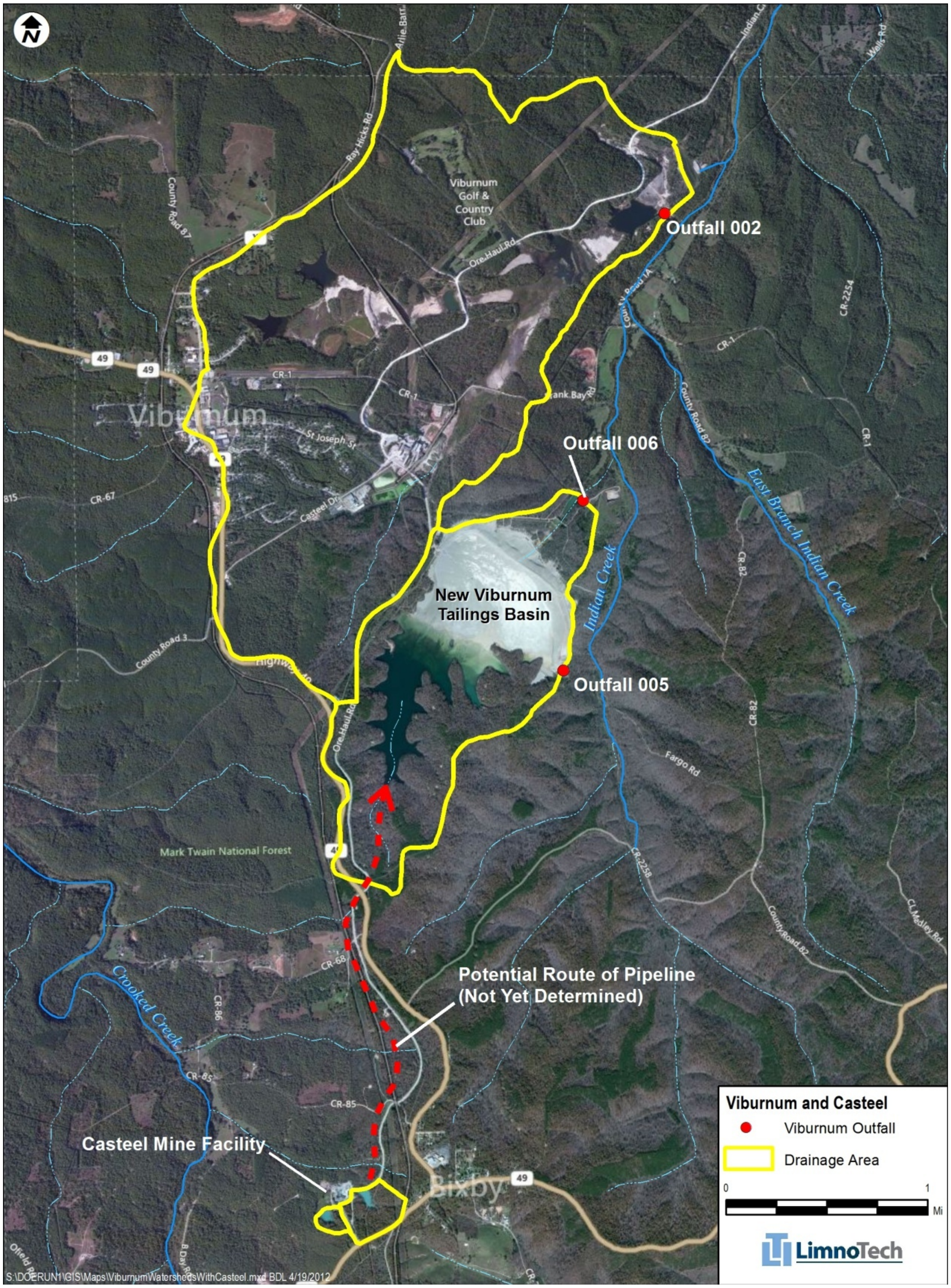


Figure 5-4. Alternative Discharge Concept for Casteel Facility

5.6 OTHER WATER MANAGEMENT MEASURES

Doe Run has evaluated options to modify the management method for storm water runoff from the Casteel ore loading area. As a result, Doe Run is currently planning to construct a storm water collection basin immediately below the ore loading area to capture storm water flows from the ore loading area and transfer such flows to mine water basin 003. Storm water reaching the storm water collection basin will be pumped to mine water basin 003 to maintain adequate storage volume within the storm water collection basin. A construction permit application including engineering plans are being prepared. The application is expected to be submitted to the Missouri Department of Natural Resources (MDNR) by August 1, 2012.

This page is blank to facilitate double sided printing.

6. PLAN IMPLEMENTATION

Implementation of the Casteel SWMP is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of the potential water management measures described in Section 5, focusing on cost-effectiveness and impact on water quality;
- Identification of water management measures;
- Implementation of identified actions;
- Monitoring of implemented actions (data collection and review);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Casteel SWMP discussed in this section are:

- Water management measure evaluations
- Monitoring
- Recordkeeping
- Training
- Coordination/interface with other plans
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections.

6.1 WATER MANAGEMENT MEASURE EVALUATIONS

Several water management evaluations are planned to support determination of the most effective and economical way to meet future final MSOP limits at Casteel, as discussed in the preceding section. These include the following:

- Completion of two pilot studies to further evaluate chemical precipitation for achieving future final MSOP limits. These tests are designed to verify the effectiveness of the technology and provide the basis for confident engineering design and cost estimation. It is expected that the pilot tests will be completed by October 1, 2012.
- Regulatory review of the potential transfer of mine water from the Casteel facility to the new Viburnum tailings basin. These may include review of antidegradation requirements and compliance with the existing TMDL for

Indian Creek. This potential action was presented to MDNR for regulatory consideration on April 12. Doe Run will request MDNR provide feedback on the concept by June 30, 2012.

- Assuming no regulatory obstacles prevent the potential transfer of mine water from the Casteel facility to the new Viburnum tailings basin, Doe Run will evaluate the technical feasibility of the mine water transfer. This evaluation of technical feasibility will be completed by September 1, 2012.
- Upon completion of the mine water treatment pilot tests currently underway, Doe Run will evaluate of the cost-effectiveness of a centralized mine water treatment plant versus a mine water treatment plant for Casteel alone. Assuming the pilot tests are completed and all results reported by October 1, 2012, Doe Run will complete this cost-effectiveness evaluation by December 31, 2012.

The schedule for each of these major activities is presented in Section 6.8, along with all other plan activities.

6.2 MONITORING

Ongoing water quality monitoring will be continued at the Casteel facility to improve the understanding of the impacts of management practices on water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 6-1 will be sampled.

Table 6-1. Surface Water Sampling Locations for the Casteel Mine.

Location	Sample ID Previously Used	Rationale
Mine water basin 001 outfall	Casteel001	Permit-required monitoring
Mine water basin 003 outfall	Casteel003	Permit-required monitoring
Main mine water inlet to basin 001	MW001	Continued monitoring of incoming mine water
Main mine water inlet to basin 003	MW003	Continued monitoring of incoming mine water
V10 mine water inlet to basin 003	Not previously sampled	Monitoring of incoming mine water
Truck wash effluent	TWEFF	Continued monitoring of truck wash effluent

These samples reflect the sampling baseline that will be continued at Casteel facility during the first plan year. Samples will be collected twice monthly at each of these locations for the first 6 months of the first plan year. After the first 6 months, if the distribution of the data indicates that twice monthly sampling is unlikely to provide a different understanding of water quality at these locations, the monitoring frequency at some or all of the locations may be reduced to monthly or quarterly. All parameters previously analyzed will continue to be analyzed and the same sample collection and analytical methods will be followed.

Future updates to this plan will describe the additional data collected and discuss how those data are used in the evaluation of management practices. In addition to the baseline monitoring described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for surface water management at Casteel facility.

6.3 RECORD-KEEPING

Best management practices are inspected at Casteel every month pursuant to the SWPPP and these inspection records will be kept on site at Casteel.

6.4 TRAINING

Training was identified in the Master Surface Water Management Plan and will be an important part of the plan for Casteel Mine. Initial training will be provided to all personnel involved in the management of water at Casteel Mine including, but not necessarily limited to:

- Maintenance personnel
- Environmental technicians

Initial training will be provided within two months of plan approval. In addition to the initial training for these personnel, annual refresher training will be conducted in conjunction with SWPPP training. The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for surface water management (including the environmental need);
- Best management practices to be used throughout the facility;
- Specific water management actions being implemented or planned;
- Water management protocols and standard operating procedures, if any;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

6.5 INTERFACE WITH OTHER PLANS

As part of an overall water management and compliance program, Doe Run has developed and maintains other plans for the Casteel Mine that include activities closely related to this plan: the Underground Water Management Plan (UWMP, LimnoTech, January 2012) and the Stormwater Pollution Prevention Plan (SWPPP; RMC, April 2011). Descriptions of how these plans relate to, and will be integrated with this Surface Water Management Plan are provided below.

6.5.1 Underground Water Management Plan

The Casteel UGWMP contains an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce solids and metals loading to surface waters at the facility from underground operations. It provides a summary of mine water flow and monitoring information and a description of activities that contribute to the presence of solids and metals in mine water. The plan provides a description of current practices used to minimize solids and metals in mine water as well as an evaluation of additional practices. The plan also provides recommendations for future activities and monitoring to support the continuing evaluation of current and potential management practices and activities for minimizing the presence of solids and associated metals in mine water pumped to the surface.

Underground water management activities can have a direct impact on water quality pumped to the surface. The following coordination activities will be conducted to ensure connectivity between the two planning efforts and to maximize the utility of the information generated by each plan:

- Changes in underground management practices will be documented and communicated between underground and surface management staff and
- Underground and above ground sampling will be coordinated (i.e. sampling will be conducted as near in time as possible) to support the evaluation of spatial and temporal trends in water quality.

Any changes in mine operation or underground water management that could affect surface water management at Casteel will be documented and, as necessary, discussed in future versions of the Casteel SWMP.

6.5.2 Storm Water Pollution Prevention Plan

The Casteel Mine Storm Water Pollution Prevention Plan (SWPPP) identifies industrial activities conducted and significant materials stored at the facility. The plan contains a description of the management practices and procedures used to minimize the exposure of activities and materials to storm water runoff. The plan also includes a description of training and inspection procedures used to track and document activities, materials, and management practices.

Any changes in storm water management activities or in the Casteel SWPPP that could affect surface water management at Casteel may be documented and, as necessary, discussed in future versions of the Casteel SWMP.

6.6 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between February 1 and April 30, 2013. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Casteel facility.

6.7 IMPLEMENTATION SCHEDULE

The schedule for the first year of water management plan implementation is presented in Table 6-2. This schedule is based on the best information available as of the date of this plan. Any deviations from this schedule will be communicated in writing to the agencies with an explanation.

Table 6-2. Implementation Schedule for First Year Surface Water Management Plan Activities at Casteel Mine.

Action	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	March 2013	April 2013
Complete mine water treatment pilot tests												
Submit construction permit application for storm water collection basin												
Regulatory review for mine water transfer from Casteel to New Viburnum Tailings[9]												
Evaluate technical feasibility & cost of water transfer												
Evaluate feasibility and cost-effectiveness of Casteel mine water treatment versus water transfer												
Training	Initial training to be provided within 2 months of plan approval											
Plan Review & Update												

[9]As stated in Section 6.1, Doe Run will submit a request to MDNR by June 30, 2012 to provide feedback on the water transfer concept. The timing for completion of the regulatory review by MDNR will be up to MDNR.

This page is blank to facilitate double sided printing.

7. REFERENCES

Barr Engineering Co. *The Doe Run Company – Casteel Mine Pilot Testing Results and Treatment System Design Basis Report*. April 2011. (Barr, 2011).

Drew, J. D., and S. Chen, 1997. *Hydrologic Extremes in Missouri: Flood and Drought*. Missouri State Water Plan Series Volume V. Missouri Department of Natural Resources, 141 pp.

Huff, F. A., and J. R. Angel, 1992. *Rainfall Frequency Atlas of the Midwest*. Illinois State Water Survey Bulletin 71, 141 pp.

LimnoTech. *Master Surface Water Management Plan*. (LimnoTech, 2011a).

LimnoTech. *Surface Water Sampling and Analysis Plan (Revision 1)*. January 6, 2011. (LimnoTech, 2011b).

LimnoTech. *Surface Water Sampling and Analysis Plan Report*. September 30, 2011. (LimnoTech, 2011c).

LimnoTech. *Underground Water Management Plan for Casteel Mine*. (LimnoTech, 2012).

Resource Environmental Management Consultants, Inc. *Stormwater Pollution Prevention Plan for Casteel Mine*. (RMC, 2011).

Resource Environmental Management Consultants, Inc. *Biotreatment Pilot Test Final Results Report*. (RMC, 2012).

U.S. Geological Survey. "History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict" (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008).

USEPA, 2009. *Urban Stormwater BMP Performance Monitoring Manual*. Chapter 7, pp. 7-10 and 7-23.

This page is blank to facilitate double sided printing.

EXHIBIT X

SURFACE WATER MANAGEMENT PLAN for the BRUSHY CREEK MINE/MILL

(MSOP No. MO-0001848)

Prepared for: The Doe Run Resources Corporation
d/b/a The Doe Run Company

May 30, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

This page is blank to facilitate double sided printing.

1. INTRODUCTION

This document presents the Surface Water Management Plan (SWMP) for the Brushy Creek Mine/Mill, prepared on behalf of The Doe Run Resources Corporation, d/b/a The Doe Run Company ("Doe Run"). The Brushy Creek SWMP has been prepared in accordance with the Master SWMP previously prepared by LimnoTech (LimnoTech, 2011). In keeping with the Master SWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to attain future final effluent limits for discharges to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Brushy Creek Mine/Mill is located in Reynolds County, Missouri, approximately 11.6 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Brushy Creek Mine/Mill (USGS, 2008).

Year	Event
1968	St. Joseph Lead Company began drilling mine shaft.
1973	St. Joseph Lead Company began production at Brushy Creek.
1973-1977	Mill complex and surface facilities constructed at Brushy Creek mine.
1983	Mine and mill shut down.
1986	St. Joseph Lead Company and Homestake Lead Company combine to form the Doe Run Company, which assumes operation of Brushy Creek Mine.
1989	Mine and mill operations resume.
Ca. 1991	Mill shut down.
Mid 1990s	Mill operations resume.

Primary surface operations at the Brushy Creek facility involve the milling of lead, zinc and copper ore from the Brushy Creek Mine, as well as occasionally receiving ore from the Casteel and Viburnum 29 mines. An aerial layout map of the Brushy Creek facility is depicted in Figure 1-2. This figure shows several features relevant to this SWMP, including the following:

- Office building – The office building at Brushy Creek has offices, employee lockers and change rooms, workshop and hoist operations.

- Mill – The mill is where ore milling occurs. The primary product of the milling process is ore concentrate or “con”, which is trucked off-site. The main by-product of the milling process is tailings, which are pumped to the tailings impoundment on site.
- Mine water basin – The mine water basin, also known as the clear water basin, receives mine water pumped to the surface from the mine and stormwater runoff from the drainage area surrounding the basin. In addition, excess water from the tailings impoundment caused by stormwater runoff from the drainage area surrounding the impoundment can be pumped to the mine water basin to relieve water levels in the tailings impoundment that may occur as a result of large precipitation events. Water collected in the mine water basin undergoes treatment via settling.
- Tailings impoundment – The tailings impoundment receives process wastewater (tailings) from the milling of lead, copper, and zinc ore, as well as stormwater runoff from the surrounding drainage area. Water collected in the impoundment undergoes treatment via settling.
- Mill reservoir – The mill reservoir receives and stores water pumped from the tailings impoundment for use in the Brushy Creek mill. Water is pumped from the mill reservoir to a standpipe which supplies water, as needed, for the truck wash and mill.
- Outfall 001 – Outfall 001 (sample ID = Brushy001) is the permitted point of discharge for mine water from the Brushy Creek facility. Mine water and stormwater, including at times excess water from the tailings impoundment are discharged through outfall 001 after undergoing treatment via settling.
- Outfall 002 – Outfall 002 (sample ID = Brushy002) is the permitted point of discharge for the tailings impoundment emergency spillway. This outfall is designed and managed as a non-discharging outfall and will only discharge in extreme precipitation events.
- Outfall 003 – Outfall 003 (sample ID = Brushy003) is the permitted point of discharge for the tailings impoundment toe drain basin. The toe drain basin collects seepage from the tailings impoundment dam, which is pumped back to the impoundment. This outfall is designed and managed as a non-discharging outfall and will only discharge in extreme precipitation events.
- Mine water box – Mine water is pumped from the Brushy Creek Mine to the surface and normally diverted to the mine water box, from which it flows to the mine water basin. Mine water flows are discussed in more detail in Section 2.1.2 of this plan. Mine water can also be diverted to the mill reservoir if needed.
- Truck wash – The truck wash cleans vehicles leaving the facility. The truck wash is described in greater detail in Section 2.1.6 of this plan.

1.2 PLAN OBJECTIVES

As stated in the Master SWMP, the objective of the site-specific SWMPs is to evaluate the technical feasibility, practicality, and effectiveness of procedures and methodologies for management of process wastewater, mine water, and stormwater associated with Doe Run mining and milling operations. The ultimate goal of this SWMP is to identify and employ water management strategies that lead to the discharge of effluent that meets applicable future final permit limits and conditions as specified in the Brushy Creek facility's Missouri State Operating Permit (MSOP).

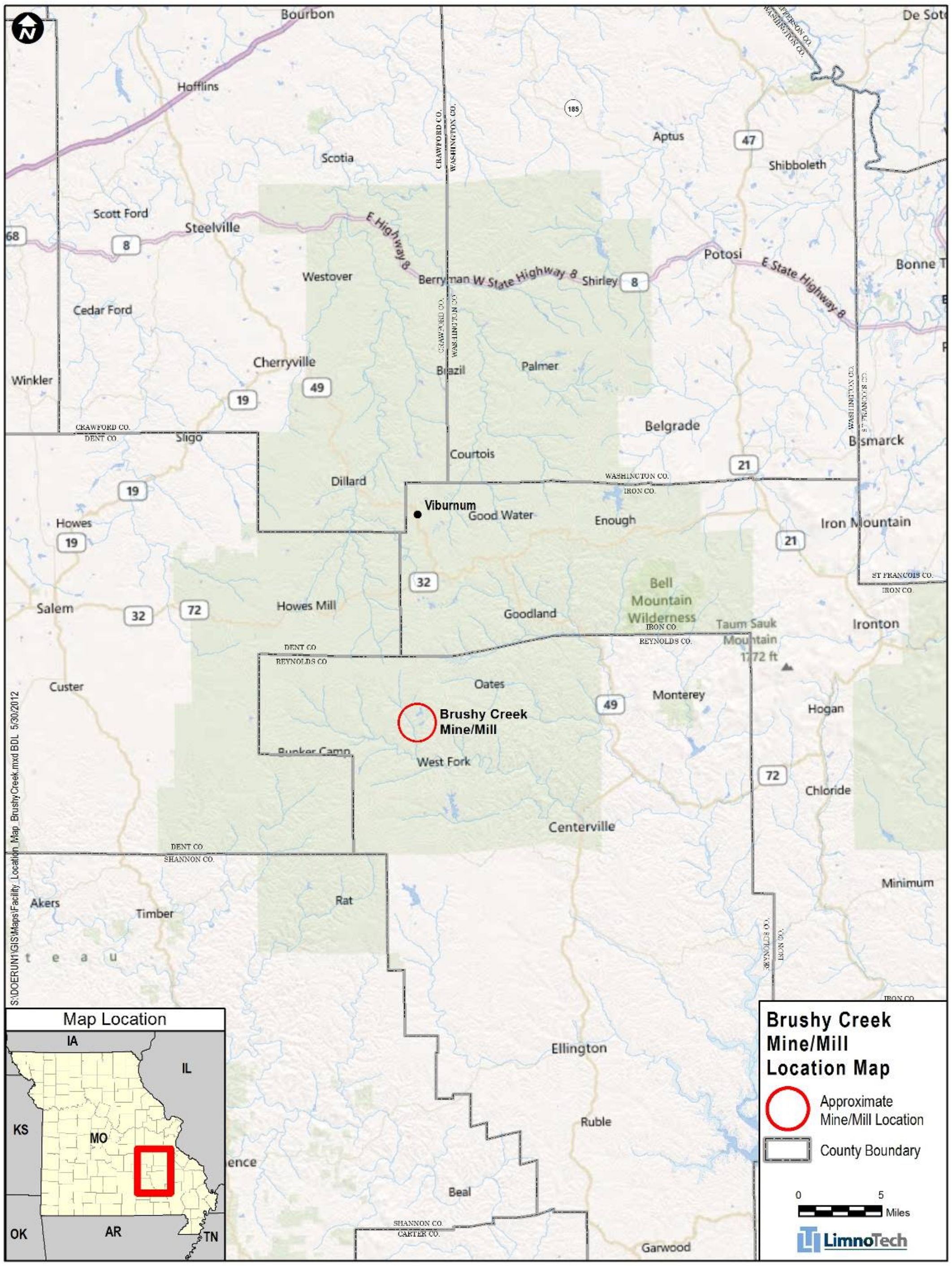


Figure 1-1. Location of the Brushy Creek Mine/Mill.

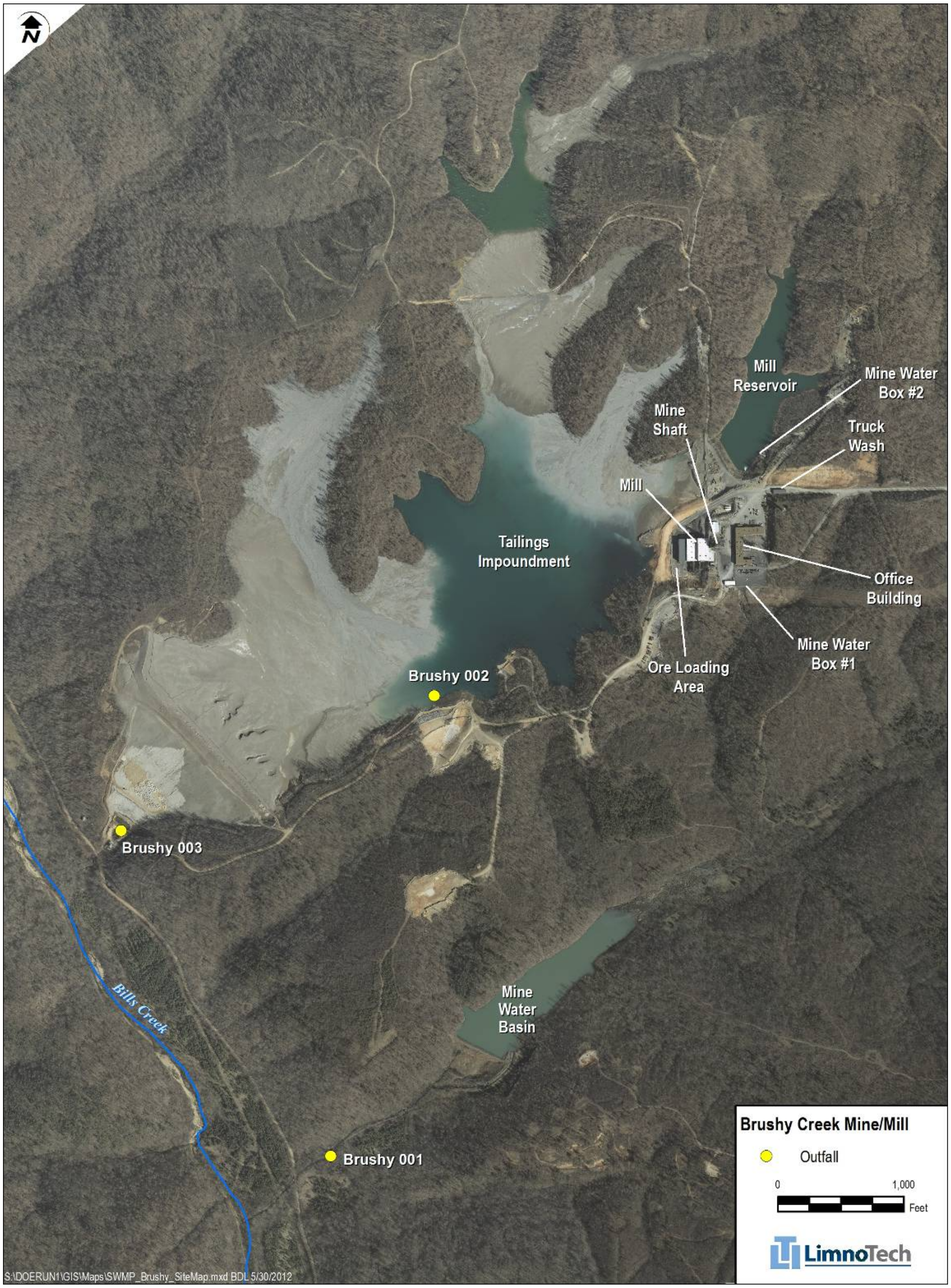


Figure 1-2. Brushy Creek Mine/Mill Layout

1.3 SCOPE OF THE SWMP

The objective of this SWMP is to evaluate the management of water associated with Doe Run operations, specifically for the identification and implementation of actions that result in attainment of future final MSOP permit limits for the Brushy Creek facility. As such, the scope includes sources, processes, flows, conditions and activities that can affect metals concentrations at permitted outfalls. It does not address other potential environmental conditions at the facility.

1.4 BRUSHY CREEK SURFACE WATER MANAGEMENT TEAM

Surface water management for the Brushy Creek facility will be the responsibility of the individuals named in Table 1-2. All of the individuals named are employees of The Doe Run Company.

Table 1-2. Brushy Creek Surface Water Management Team.

Job Title	Name	Contact Info	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	#35 Iron County Rd. #1 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mill Manager	John Boyer	P.O. Box 500 Viburnum, MO 65566 573-689-4263	Oversight and management of Doe Run mill operations
Chief Engineer	Dan Buxton	P.O. Box 500 Viburnum, MO 65566 573-244-8142	Oversight of major water management measures evaluation and design
General Maintenance Manager	Gene Hites	P.O. Box 500 Viburnum, MO 65566 573-689-4151	Management of facility maintenance issues and personnel
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573- 689-4535	Environmental data collection, management, and reporting
Brushy Creek Mill Superintendent	Adam Steimel	P.O. Box 500 Viburnum, MO 65566 573-689-4222	Brushy Creek SWMP Primary Oversight, Implementation
Brushy Creek General Maintenance Supervisor	Jorge Sulca	P.O. Box 500 Viburnum, MO 65566 573-689-4230	Brushy Creek SWMP Secondary Oversight, Implementation, and record-keeping
Brushy Creek Surface Maintenance Supervisor	Ronny Parker	P.O. Box 500 Viburnum, MO 65566 573-689-4227	Brushy Creek SWMP Secondary Oversight, Implementation

This page is blank to facilitate double sided printing.

2. WATER INVENTORY

As required by the Master SWMP, the components of surface water flow at the Brushy Creek facility are discussed in detail in this section and their relative contributions to the overall water balance at the facility are presented. Each major surface water flow component is described in Section 2.1 and the overall facility surface water balance for each outfall is described in Section 2.2. The water inventory for the facility is characterized with respect to the mine water basin (outfall 001) which is the only outfall that discharges under normal operating conditions.

2.1 SURFACE WATER FLOW COMPONENTS

The major components of surface water flow for the Brushy Creek facility are:

- Outfall flows
- Mine water
- Direct precipitation
- Evaporation
- Stormwater runoff
- Truck wash water
- Infiltration

Each of these flow sources is discussed below.

2.1.1 Outfall Flows

Monthly flow measurements have been manually collected by Doe Run at the mine water basin outfall 001 since January 2006. Through March 2012, 88 measurements have been collected at the outfall. The average flow measurement for outfall 001 for this period was 3.2 MGD. The flow data are shown in Figure 2-1.

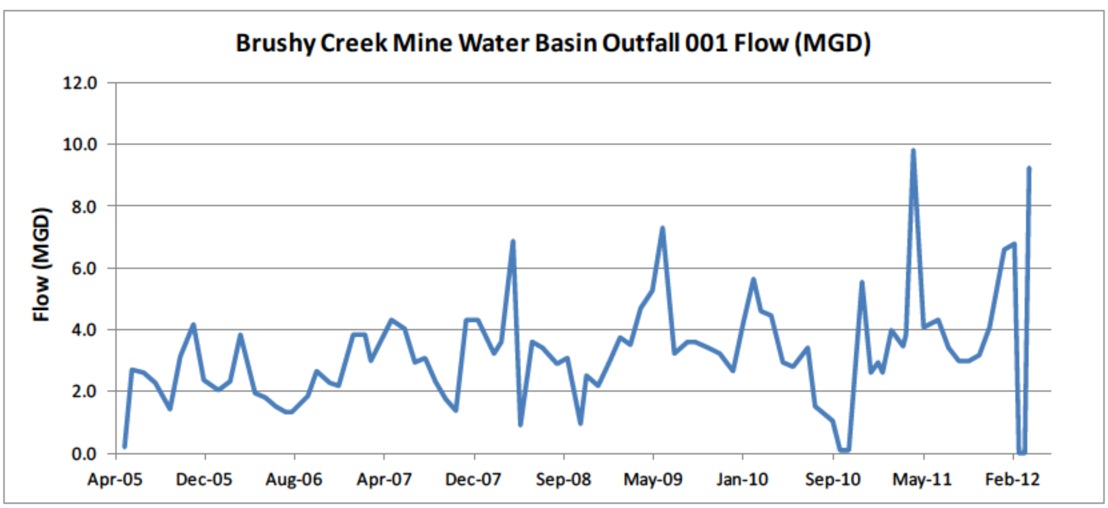


Figure 2-1. Measured Brushy Creek Outfall Flows (Jan. 2006 - Jan. 2012).

The average, minimum and maximum flows for each month of the year were calculated from these data and are presented in Table 2-1.

Table 2-1. Monthly Outfall Flows for the Brushy Creek Facility.

	Brushy Creek Outfall 001		
Month	**Ave**	**Min**	**Max**
Jan	3.69	2.02	6.59
Feb	3.57	2.31	5.65
Mar	3.75	2.99	4.60
Apr	3.66	0.19	6.87
May	3.97	0.92	9.80
Jun	3.70	1.51	7.31
Jul	2.99	1.31	4.31
Aug	2.46	1.31	3.59
Sep	2.63	1.04	3.59
Oct	1.98	0.08	3.41
Nov	2.41	0.08	4.17
Dec	3.34	2.20	5.54

The average monthly flows for Brushy Creek outfall 001 are shown graphically in Figure 2-2, using the 2006 – 2012 data.

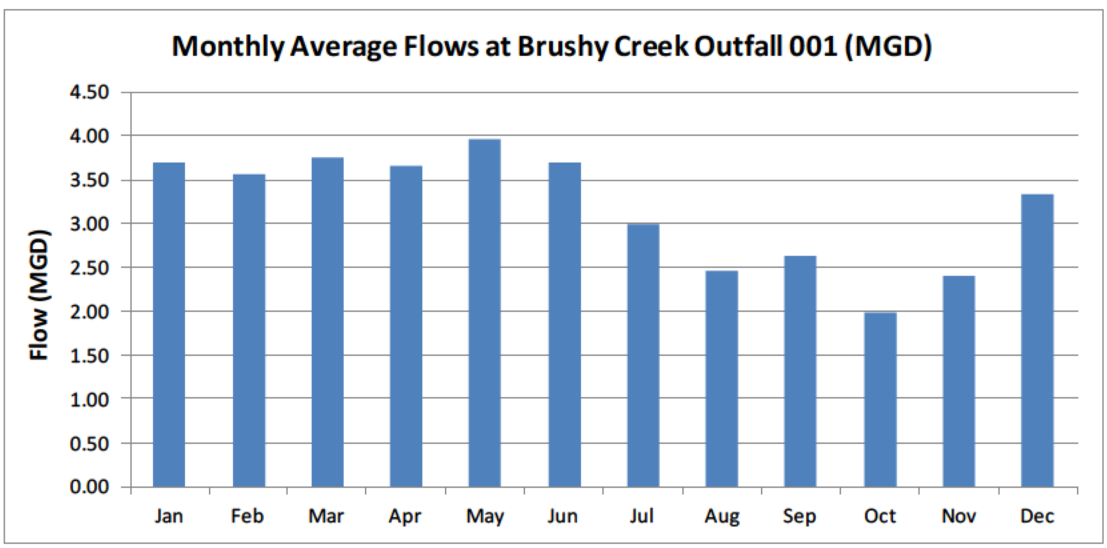


Figure 2-2. Monthly Average Flows at Brushy Creek Outfall 001 (based on monthly flow measurements collected 2006 through 2012).

Because the Brushy Creek mine water basin receives mine water, direct stormwater runoff from the drainage area surrounding the basin, and excess water pumped from the tailings impoundment, the monthly variability in flows likely has more to do with the rainfall variability than it does mine water pumping variability. Stormwater runoff is discussed in Section 2.1.5.

2.1.2 Mine Water

Mine water from the Brushy Creek Mine is pumped to the surface at the mine shaft and is diverted to either the mine water box or the mill reservoir inlet, or both. Mine water flows from the mine water box to the mine water basin. Based on the operating experience of mine personnel and the sizes and capacities of the pumps in place at Brushy Creek Mine, the best estimate of mine water pumped to the surface from the mine is tabulated in Table 2-2, as reported in the *Underground Water Management Plan for Brushy Creek Mine* (LimnoTech, 2012).

Table 2-2. Mine Water Flowrates at Brushy Creek Mine, as Estimated by Mine Personnel.

Quantity	Value
Average Flow Pumped to Surface (current)	2,300 gpm
Maximum Mine Water Pumping Capacity (current)	5,000 gpm

Mine water flow rates at Brushy Creek are not measured at the surface.

2.1.3 Precipitation

Precipitation is important in understanding both direct volume contribution to the mine water basin and tailings impoundment, and in calculating stormwater flows. Doe Run has operated a rain gage at the Brushy Creek Mine/Mill facility since 2009, which provides useful data for evaluating stormwater response to precipitation events. However, the gage has not collected data for a long enough period to evaluate long-term trends or averages, which typically requires a relatively long period of record, usually decades. Two sources of long-term rainfall data near the Brushy Creek facility are:

- National Climatic Data Center (NCDC) Viburnum gage (#238609) – The NCDC has operated a rain gage in Viburnum since 1971.
- NCDC Salem gage (#237506) – The NCDC has operated a rain gage in Salem since 1979.

These rain gages are summarized in Table 2-3 and their locations relative to the Brushy Creek facility are shown in Figure 2-3. Based on their relatively long periods of record, either of the NCDC gages could be used to calculate long-term average values.

Table 2-3. Summary of Rain Gages Near Brushy Creek Facility.

Rain Gage	Period of Record	Data Frequency	Distance to Brushy Creek Facility (miles)
NCDC Viburnum (#238609)	1971 – 2011	15 minute	12.5
NCDC Salem (#237506)	1979 - 2011	15 minute	22.9

Inspection of the gage data from the two NCDC gages shows that each gage has had several years when data were only recorded for part of the year. In fact, only nine of the 40 years of operation for the Viburnum gage had a complete data set and only 11 out of 32 years at the Salem gage had a complete data set. Using only the complete data years, the Salem gage had a long-term average rainfall of 37.4 inches and the Viburnum gage had a long-term average rainfall of 38.7 inches. The average of these two is 38 inches.

Using the average annual rainfall value of 38 inches, the volume contribution of direct precipitation to the Brushy Creek mine water basin and tailings impoundment (including the mill reservoir) can be calculated, as shown in Table 2-4.

Table 2-4. Calculation of Average Annual Direct Precipitation to the Brushy Creek Mine Water Basin and Tailings Impoundment

Mine Water Basin	Surface Area (acres)	Average Annual Rainfall (in)	Average Annual Rainfall Volume (MG)	Average Daily Rainfall Flow (MGD)
Mine Water Basin	12	38	12	0.034
Tailings Impoundment (including Mill Reservoir)	243[1]	38	250	0.69

[1] This includes open water areas and beach areas in the tailings impoundment, as well as the mill reservoir.

2.1.4 Evaporation

Both the mine water basin and the tailings impoundment have relatively large, exposed water surfaces that are subject to volume loss by evaporation. Evaporation data were obtained from the NCDC Lakeside Station, which has a period of record from 1948 to 1990. This station was located approximately 100 miles from the Brushy Creek facility. The average annual free water surface evaporation calculated from these data is about 38 inches per year, which is at the low end of the range for Missouri (Drew and Chen, 1997). This average also happens to be equal to the long-term average annual rainfall. For purposes of the overall annual water balance, this annual evaporation rate was converted to a daily "flow" as shown in Table 2-5.

Table 2-5. Calculation of Average Annual Evaporation from the Brushy Creek Mine Water Basin and Tailings Impoundment

Mine Water Basin	Surface Area (acres)	Average Annual Evaporation (in)	Average Annual Evaporation Volume (MG)	Average Daily Evaporation "Flow" (MGD)
Mine Water Basin	12	38	12	0.034
Tailings Impoundment (including Mill Reservoir)	89[2]	38	92	0.25

The estimated average annual evaporation rate (38 inches) is equal to the estimated average annual rainfall for Brushy Creek. Although these two quantities are equal, they do not occur at the same time and do not necessarily cancel each other out in the water balance, except on an annual basis.

[2] This includes only open water surface in the tailings impoundment and mill reservoir.

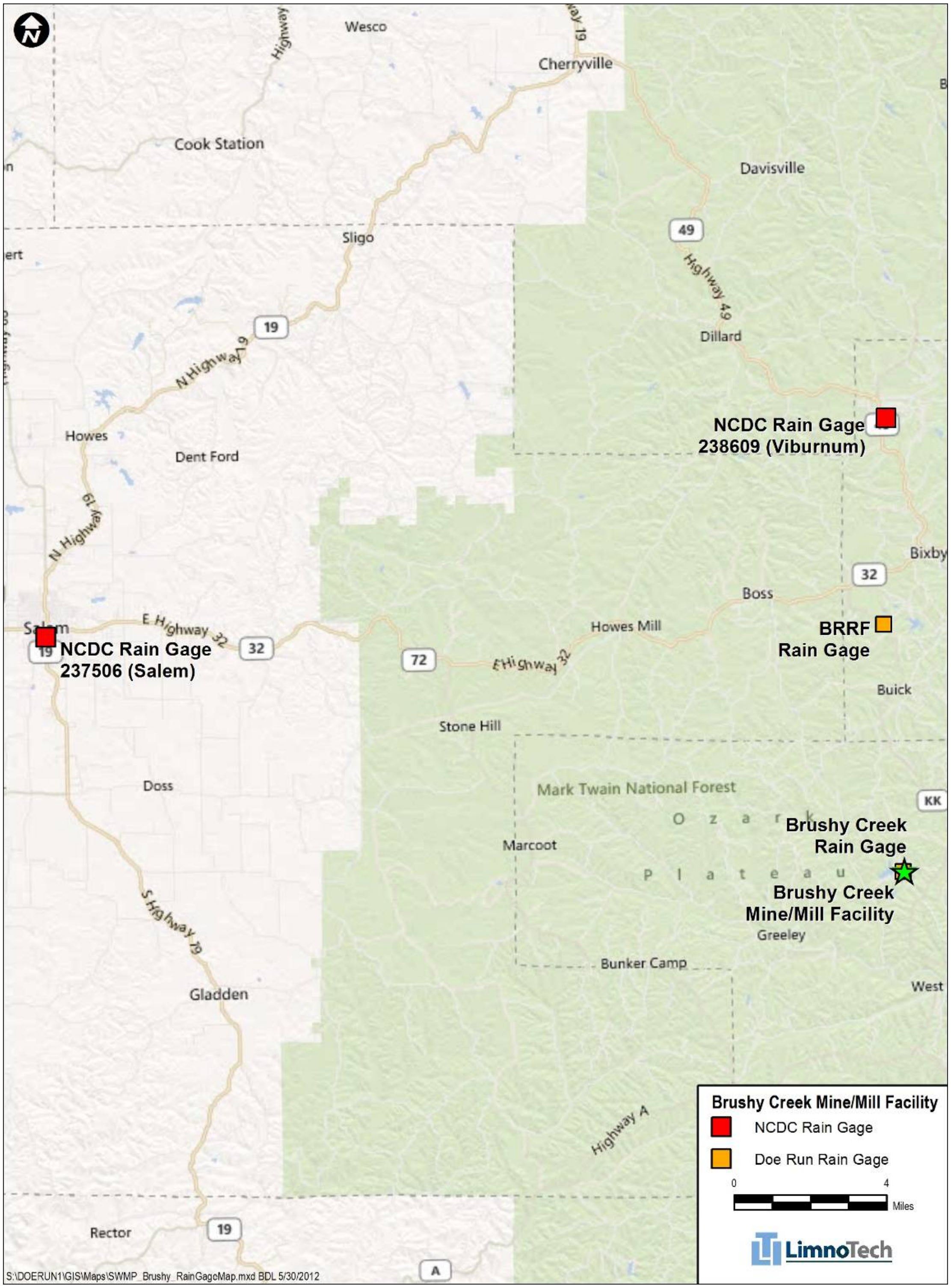


Figure 2-3. Nearest Rain Gages to the Brushy Creek Facility.

2.1.5 Stormwater Runoff

Stormwater provides a source of flow to both the mine water basin and the tailings impoundment at the Brushy Creek facility. Figure 2-4 shows the drainage areas contributing stormwater flows to the mine water basin and the tailings impoundment. The Brushy Creek mine water basin has a drainage area of approximately 1,190 acres and the tailings impoundment has a drainage area of approximately 650 acres.

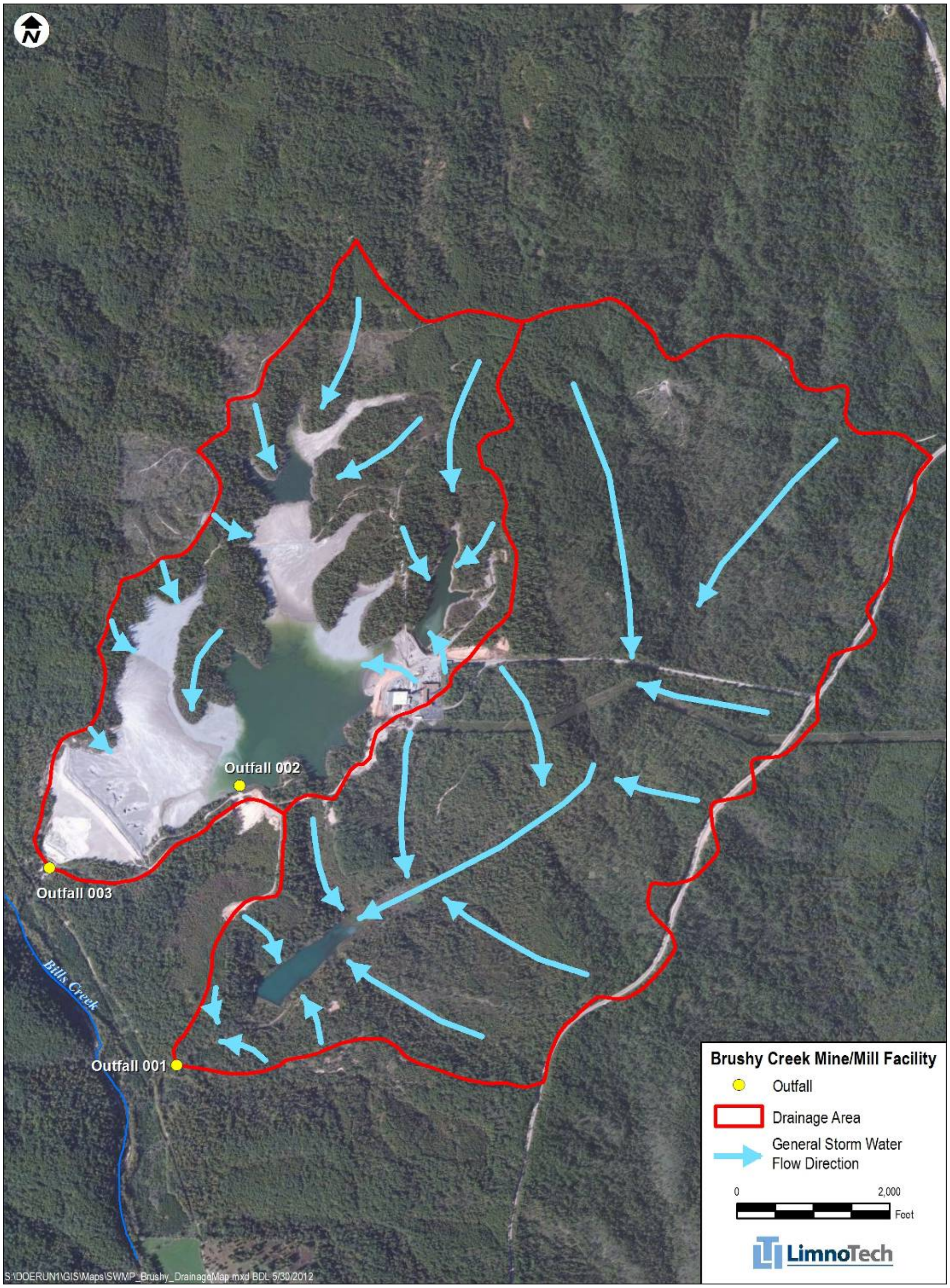


Figure 2-4. Stormwater Drainage Areas and Flow Paths at the Brushy Creek Facility

A USEPA Stormwater Management Model (SWMM) was constructed to simulate stormwater runoff to the mine water basin and the tailings impoundment at the Brushy Creek facility from their contributing drainage areas. The drainage areas to the mine water basin and the tailings impoundment were individually delineated in ArcGIS using 10-meter elevation data. Soils, land use, and slope data were used to determine runoff characteristics using the Green and Ampt method for each drainage area and these data were input into SWMM.

To support development of the SWMM model and the estimation of stormwater runoff volume, a continuous flow meter was installed at the Parshall flume downstream of the mine water basin from March 30, 2012 through May 14, 2012. The rationale for this installation was that storm response could be separated from base flow (either natural base flow alone or natural base flow plus mine water flow) and the volume of runoff generated to the mine water basin from a storm event could be quantified with a degree of accuracy sufficient for purposes of developing a water balance. Once the runoff volume was determined, the results could be compared to the runoff predicted by the model and the model parameters could be adjusted to better match the predicted and actual runoff volumes. Although this would not provide a rigorous calibration of the model, it would improve the model's accuracy.

Rain data from the Brushy Creek rain gage for the period of April 2009 through May 2012 was used in the Brushy Creek SWMM model to simulate runoff and to calculate an average runoff/rainfall ratio, which is an estimate of the average portion of rainfall that becomes runoff to the mine water basin and the tailings impoundment. This ratio will vary with rainfall intensity but the average value is a reasonable indicator of the average runoff flow. This approach resulted in an average runoff/rainfall ratio of 0.07 for the mine water basin drainage area and 0.16 for the tailings impoundment drainage area. The difference in ratios is mainly due to the longer flow paths for runoff in the mine water basin, leading to more infiltration and lower runoff. These ratios were applied to the long-term average annual rainfall discussed in the preceding section and a long-term average annual runoff contribution to the mine water basin and tailings impoundment was calculated. Using this approach, the long-term average annual rainfall of 38 inches was used with the model-derived runoff/rainfall ratio and the drainage areas of the mine water basin and the tailings impoundment to calculate average annual runoff flows, as summarized in Table 2-6.

Table 2-6. Calculation of Average Annual Runoff Flows to the Brushy Creek Mine Water Basin and Tailings Impoundment

Basin	Drainage Area (acres)	Average Annual Rainfall (in)	Average Annual Rainfall Volume (MG)	Runoff/ Rainfall Ratio	Average Annual Runoff Volume (MG)	Average Daily Runoff Flow (MGD)
Mine Water Basin	1,190	38	1,228	0.07	86	0.24
Tailings Impoundment	650	38	671	0.16	107	0.29

The model was then run for a suite of design storms of 24-hour duration, summarized in Table 2-7, to evaluate the variability of the runoff/rainfall ratio.

Table 2-7. Characteristics of 24-hour Storm Events (Huff and Angel, 1992) and Variation of Runoff/Rainfall Ratios

Recurrence (years)	Duration (hours)	Rainfall Depth (inches)	Model-Derived Runoff/ Rainfall Ratio
1	24	2.79	0.11
2	24	3.51	0.22
5	24	4.39	0.33
10	24	5.03	0.41
25	24	5.94	0.49

These results show that the runoff/rainfall ratio will increase with storm intensity and can be many times higher than the long-term average.

In addition to direct runoff, Doe Run occasionally pumps excess water from the tailings impoundment to the mine water basin, to avoid overtopping the tailings impoundment emergency spillway. This type of transfer is infrequent. A conservative estimate by Doe Run personnel of the quantity of water pumped on these occasions is 3,000 gpm for two weeks. On an annualized basis, this is equivalent to 0.165 MGD, but the infrequent nature of the pumping means it is not a significant component of the overall water balance at Brushy Creek.

2.1.6 Truck Wash Water

Water for the Brushy Creek truck wash is taken from the process water line that feeds the mill which, in turn, is pumped from the mill reservoir. During the truck washing process, water is collected in floor drains inside the truck wash building and drained to a concrete settling basin beneath the truck wash. This allows solids to settle and the clarified water drains by gravity back to mill reservoir. The truck wash process is, therefore, a closed-loop process and does not represent either a net gain or loss with respect to the flow through the mill reservoir.

The truck wash is designed to spray each truck for a minimum of 45 seconds at a flow of 500 gpm to 1,000 gpm, therefore a reasonable estimate of the truck wash water usage is 700 gallons per truck. Records at the Brushy Creek facility indicate that the average number of trucks leaving Brushy Creek and passing through the truck wash monthly is about 363 for an annual average of about 4,352 trucks per year. At 700 gallons per truck, this means that approximately 3 million gallons of water from the mill reservoir are used for washing, cycled through the truck wash and discharged back to the mill reservoir every year, for an average daily flow of 0.008 MGD.

As mentioned above, this is a closed loop process and does not represent a net increase in flow through the basin. However, truck wash water may represent a net increase in solids loading to the basin, which may affect metals concentrations. The impact of discharging truck wash water into the mill reservoir at Brushy Creek is discussed in Section 3.3.3 of this plan.

2.1.7 Infiltration

Because the tailings impoundment and mine water basin were not constructed with liners, the possibility of some infiltration exists. For purposes of the overall water balance, infiltration was estimated using Darcy's law and available data. Darcy's law is:

$$Q = AK(dH/dL)$$

Where:

Q = infiltration flow (cfs)

A = surface area (ft^2)

K = hydraulic conductivity (ft/sec)

dH = vertical head difference between impoundment water surface and groundwater table (ft)

dL = horizontal distance between impoundment and downstream well where groundwater table elevation is measured (ft)

Estimates of infiltration were made separately for the tailings impoundment and the mine water basin. Each variable in the equation above was estimated using available data as described in Table 2-8 below:

Table 2-8. Parameters Used to Estimate Infiltration from Brushy Creek Tailings Impoundment

Parameter	Description	Value
Surface area	Used surface area of tailings impoundment, including open water and beach, measured from recent aerial photograph	234 acres (10,193,040 ft^2)
Hydraulic conductivity	Used estimated conductivity of tailings solids (based on grain size distribution of tailings) assumed to be covering bed of impoundment; median (D_{50}) grain size of 0.06 mm, classified as silt; horizontal hydraulic conductivity of silt ~ 10^{-4} to 10^{-6} cm/s; used median of 10^{-5} cm/s, but divided by 10 to represent lower vertical hydraulic conductivity	10^{-6} cm/sec (3.28×10^{-8} ft/sec)
Vertical head difference	Typ. water surface elevation in impoundment (1188 ft.) minus typ. groundwater elev. in well P3, immediately downstream of the tailings dam (1003 ft), based on last 2 yrs of data	185 ft
Horizontal distance	Horizontal distance between monitoring well P3 and open water in the tailings impoundment	1,000 ft

The parameter values in Table 2-8 yield an estimated infiltration rate from the Brushy Creek tailings impoundment of 28 gallons per minute or 0.04 MGD. The same approach was used to estimate infiltration from the mine water basin, using the parameters summarized in Table 2-9.

Table 2-9. Parameters Used to Estimate Infiltration from Brushy Creek Mine Water Basin

Parameter	Description	Value
Surface area	Used surface area of mine water basin, including open water and beach, measured from recent aerial photograph	12 acres (522,720 ft^2)
Hydraulic conductivity	Used estimated conductivity of shallow native soils in vicinity of the mine water basin, as determined in previous hydrogeologic investigation at monitoring well P3 (Simon Hydro-Search, 1992), but divided by 10 to represent lower vertical hydraulic conductivity	4.9×10^{-6} ft/sec)
Vertical head difference	Water surface elevation in mine water basin (1045 ft) minus stream elevation downstream of basin (1000 ft)	45 ft
Horizontal distance	Horizontal distance between elevation measurements	500 ft

The parameter values in Table 2-9 yield an estimated infiltration rate from the Brushy Creek mine water basin of 103 gallons per minute or 0.15 MGD. Infiltration from the basin is not significant and therefore does not have an impact on the water balance.

2.2 FACILITY WATER BALANCE

The calculations of flows to and from the Brushy Creek mine water basin and tailings impoundment, described in the preceding sections of this plan, were combined to produce an overall water balance for the mine water basin and tailings impoundment. A schematic of the water balance for the Brushy Creek mine water basin and tailings impoundment is presented in Figure 2-5.

Where flows are infrequent or irregular, the flow paths are shown as dashed lines in this figure. Flow rates are not shown where flow is very infrequent, such as at outfalls 002 and 003. It is important to note that mine water is, by far, the major source of flow to the mine water basin (and outfall 001) on an annual basis. The flow rates shown generally balance, accounting for some inherent uncertainty in the estimates.

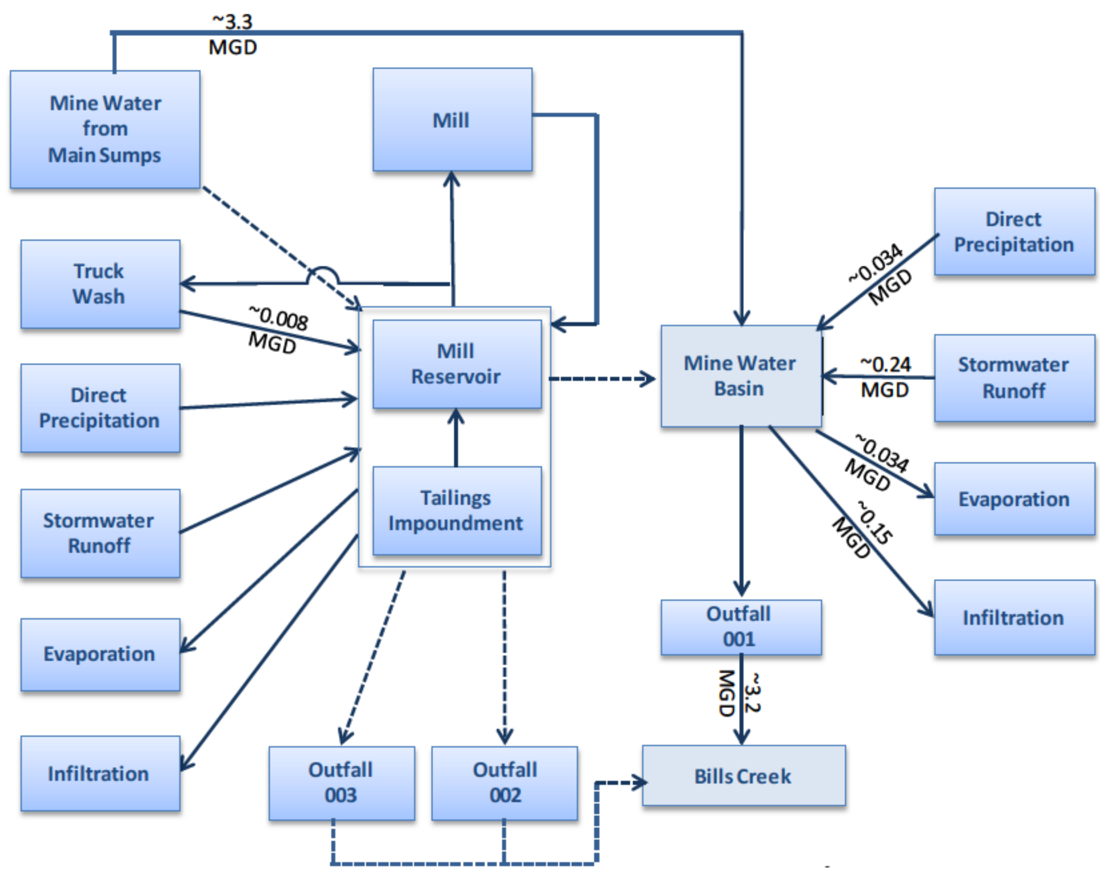


Figure 2-5. Overall Water Balance for Brushy Creek Mine Water Basin and Tailings Impoundment.

3. SOURCE IDENTIFICATION

As stated in the Master SWMP (LimnoTech, 2011a), the source identification component of the Site-Specific SWMP involves identifying and investigating the potential sources of target metals to surface water at each facility and identifying the pathways by which metals might enter surface water flows. This section of the Brushy Creek SWMP describes the following components of the source identification process at the facility:

- Surface Water Data Summary – An overview of the data used in this SWMP.
- Outfall Data Assessment – A review of outfall monitoring data to identify priorities for the Surface Water Management Plan.
- Sources of Metals Loading to Outfalls – Describes each potential source of metals loading to outfall 001: mine water, stormwater runoff, truck wash water and excess water pumped from the tailings impoundment to the mine water basin.
- Source Assessment Summary – Summarizes the sources evaluated for the Brushy Creek facility and presents conclusions.

Further discussion of the fate and transport of metals from these sources is presented in Section 4 of this plan.

3.1 SURFACE WATER DATA SUMMARY

The analysis to support the Brushy Creek SWMP relies on data from three different sampling efforts, which are described in greater detail below:

- Monthly outfall sampling as required by the Brushy Creek facility's MSOP.
- Sampling conducted specifically for the SWMP in March-May 2011, as outlined in the Surface Water Sampling and Analysis Plan (LimnoTech, 2011b).
- Supplemental semi-monthly sampling conducted since September 2011 to support SWMP preparation.

Surface water samples collected at Brushy Creek are summarized in Tables 3-1 and 3-2. Station Brushy001 refers to outfall 001, which is the outlet for the Brushy Creek mine water basin. This is the only outfall location at Brushy Creek that has consistent flow. Stations Brushy002 and Brushy003 refer to the tailings impoundment emergency spillway and the tailings impoundment toe drain basin, respectively. These outfalls are designed and managed as non-discharging outfalls and discharge only in extreme precipitation events. Normally, excess water in the tailings impoundment is pumped to the mine water basin to avoid discharge from 002. The toe drain basin water is pumped back to the tailings impoundment. Sampling is performed at outfall 001 pursuant to the MSOP (Brushy001), but because outfalls 002 and 003 are non-discharging (except for extreme precipitation events), Doe Run does not have data for these outfalls. Sampling at outfall 001 (Brushy001) for total metals and total suspended solids has been conducted since January 2005. Analysis of dissolved metals began in January 2006.

Table 3-1. Surface Water Data Availability for Total Metals and Solids at Brushy Creek Facility, by Station[3]

Brushy001	1/2006-2/2012	136	136	140	161	116
Brushy002	No Data					
Brushy003	No Data					
BC-MillInf	12/9/10, 5/17/11	2	2	2	2	2
BC-MWB1BOT	4/12/11	1	1	1	1	1
BC-MWB1SUR	4/12/11	1	1	1	1	1
BC-MWB2BOT	4/12/11	1	1	1	1	1
BC-MWB2SUR	4/12/11	1	1	1	1	1
BC-MWB3BOT	4/12/11	1	1	1	1	1
BC-MWB3SUR	4/12/11	1	1	1	1	1
BC-MWBEff	12/9/10 - 2/21/12	13	13	13	13	13
BC-MWBox	12/9/10 - 2/21/12	13	13	13	13	13
BC-TI1BOT	4/12/11	1	1	1	1	1
BC-TI1SUR	4/12/11	1	1	1	1	1
BC-TI2SBOT	4/12/11	1	1	1	1	1
BC-TI2SUR	4/12/11	1	1	1	1	1
BC-TI3BOT	4/12/11	1	1	1	1	1
BC-TI3SUR	4/12/11	1	1	1	1	1
BC-TI4BOT	4/12/11	1	1	1	1	1
BC-TI4SUR	4/12/11	1	1	1	1	1
BC-TIBargePump	12/9/10 - 2/21/12	13	13	13	13	13
BC-TrkWshEff	12/9/10, 5/17/11	2	2	2	2	2

[3] On-site sample locations only; receiving water sample locations are not listed.

Table 3-2. Surface Water Data Availability for Dissolved Metals at Brushy Creek Facility, by Station

Brushy001	1/2006-2/2012	96	96	96	96
Brushy002	No Data				
Brushy003	No Data				
BC-MillInf	12/9/10, 5/17/11	2	2	2	2
BC-MWB1BOT	4/12/11	1	1	1	1
BC-MWB1SUR	4/12/11	1	1	1	1
BC-MWB2BOT	4/12/11	1	1	1	1
BC-MWB2SUR	4/12/11	1	1	1	1
BC-MWB3BOT	4/12/11	1	1	1	1
BC-MWB3SUR	4/12/11	1	1	1	1
BC-MWBEff	12/9/10 - 2/21/12	13	13	13	13
BC-MWBox	12/9/10 - 2/21/12	13	13	13	13
BC-TI1BOT	4/12/11	1	1	1	1
BC-TI1SUR	4/12/11	1	1	1	1
BC-TI2SBOT	4/12/11	1	1	1	1
BC-TI2SUR	4/12/11	1	1	1	1
BC-TI3BOT	4/12/11	1	1	1	1
BC-TI3SUR	4/12/11	1	1	1	1
BC-TI4BOT	4/12/11	1	1	1	1
BC-TI4SUR	4/12/11	1	1	1	1
BC-TIBargePump	12/9/10 - 2/21/12	13	13	13	13
BC-TrkWshEff	12/9/10, 5/17/11	3	3	3	3

Sampling procedures and analytical methods were documented in a surface water sampling and analysis plan (SWSAP) report in 2011 (LimnoTech, 2011c). Three discrete sampling events were conducted at Brushy Creek on 12/10/2010, 4/12/2011, and 5/17/2011. Not every location was sampled during every event, but every location in Tables 3-1 and 3-2 was sampled during at least one event.

Beginning in September 2011, stations Brushy001, MWBox, MWBEff, and TIBargePump were sampled twice/month to provide additional data in support of the Brushy Creek SWMP. At the time of this report, semi-monthly data have been received and validated through February 2012. These sample locations are shown in Figure 3-1.

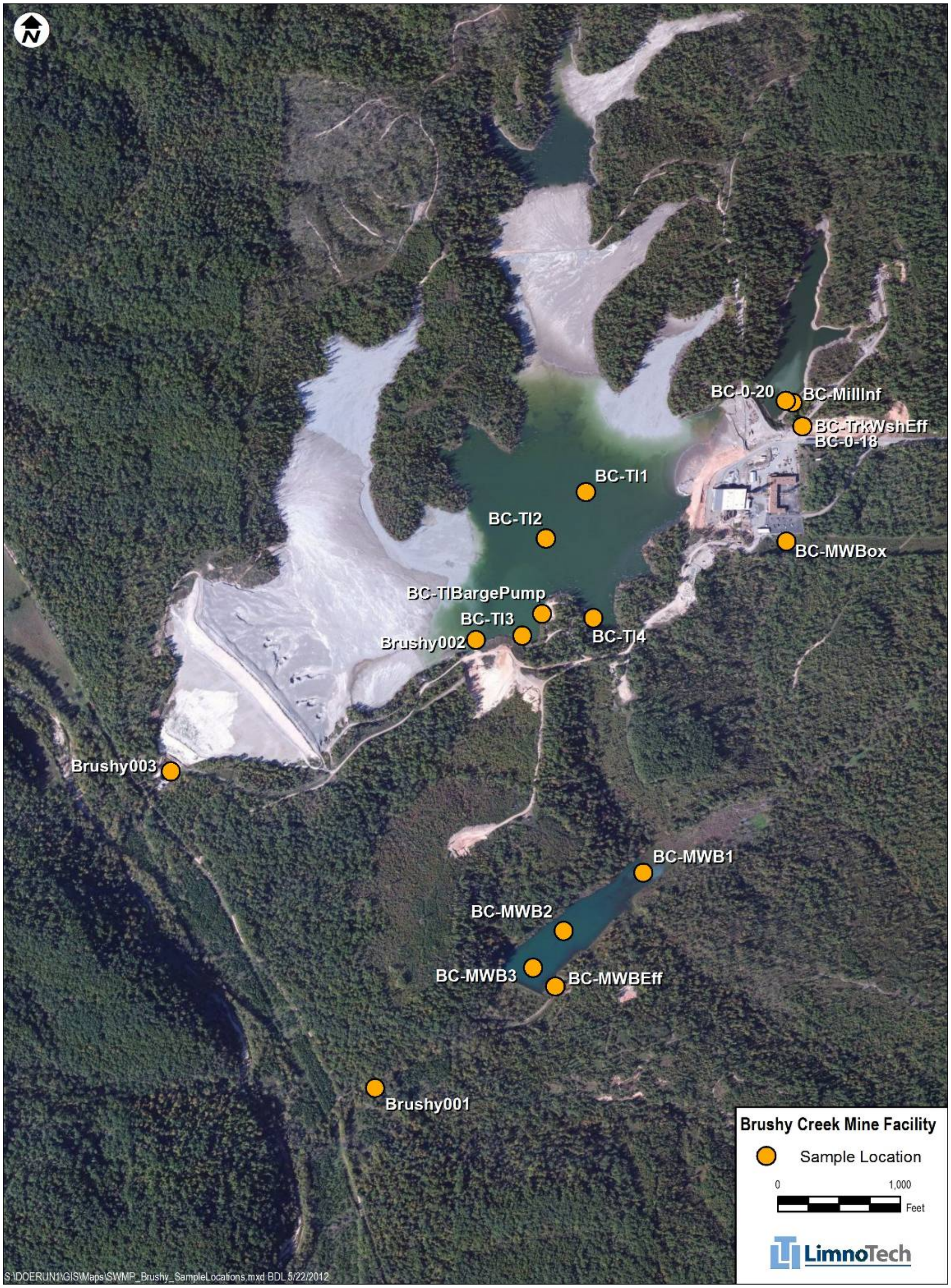


Figure 3-1. Brushy Creek Surface Water Sample Locations

3.2 OUTFALL DATA ASSESSMENT

The primary objective of this SWMP is to evaluate procedures and methodologies for management of water with the ultimate goal of discharging effluent that meets applicable future final MSOP limits, therefore the Brushy Creek outfall data were analyzed to identify priorities for water management. The following sections present the following evaluations:

- Comparisons of outfall data to future final MSOP limits
- Comparison of total and dissolved metals in effluent at the outfalls
- Evaluation of seasonal variability of the outfall data.

3.2.1 Comparison of Outfall Data to Future Final MSOP Limits

Effluent monitoring data from the Brushy Creek mine water basin were evaluated in reference to the future final discharge limits in the MSOP for the Brushy Creek Mine/Mill which become effective in February 2013. The limits for the primary constituents of interest for outfall 001 are summarized in Tables 3-3.

Table 3-3. Future Final MSOP Limits for the Brushy Creek Mine/Mill (Outfall 001)

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Cadmium, total recoverable	1.3	0.6
Copper, total recoverable	61.0	30.4
Lead, total recoverable	23.3	11.6
Zinc, total recoverable	370.0	184.6

Effluent limits for outfalls 002 (tailings impoundment toe drain discharge) and 003 (tailings impoundment emergency spillway) are also specified in the Brushy Creek MSOP, but are not presented here because these locations are designed and managed as non-discharging outfalls and therefore only discharge under emergency conditions of extremely high stormwater flows. As such, no data were collected during the monitoring period.

3.2.1.a Time Series Plots for Brushy Creek Outfall Data

Time-series plots of total metals concentrations at outfall 001 for cadmium, copper, lead, zinc, and TSS are presented on the following pages. Future final MSOP effluent limits are shown on the plots to facilitate comparison of data with those limits.

Total cadmium data are shown in Figure 3-2 for outfall 001 for the time period of June 2010 through February 2012[4]. During the time period shown, 30 samples at outfall 001 (59%) were higher than the future final daily maximum limit, and nearly all (98%) samples were higher than the future final monthly average limit for cadmium at 001.

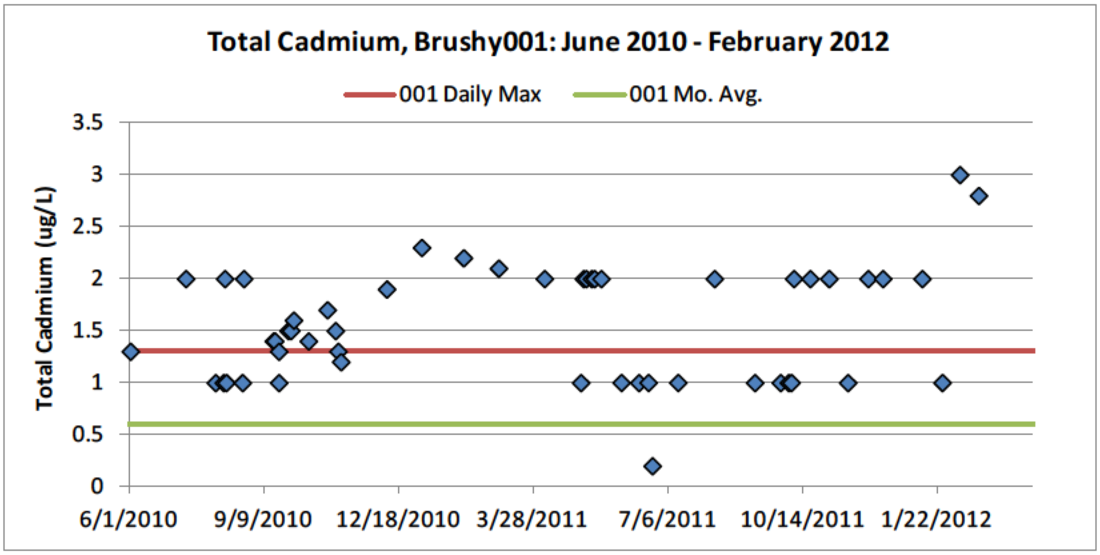


Figure 3-2. Time Series Plot for Total Cadmium at Brushy001, June 2010-February 2012

Total copper effluent data are shown in Figure 3-3 for outfall 001. Between January 2005 and February 2012, 100% of all effluent samples were below both the future final daily maximum and future final monthly average MSOP limits for total copper.

[4] These dates were selected because prior to June 2010, a detection limit of 5-10 µg/L was used for cadmium, which exceeds all MSOP limits for total cadmium.

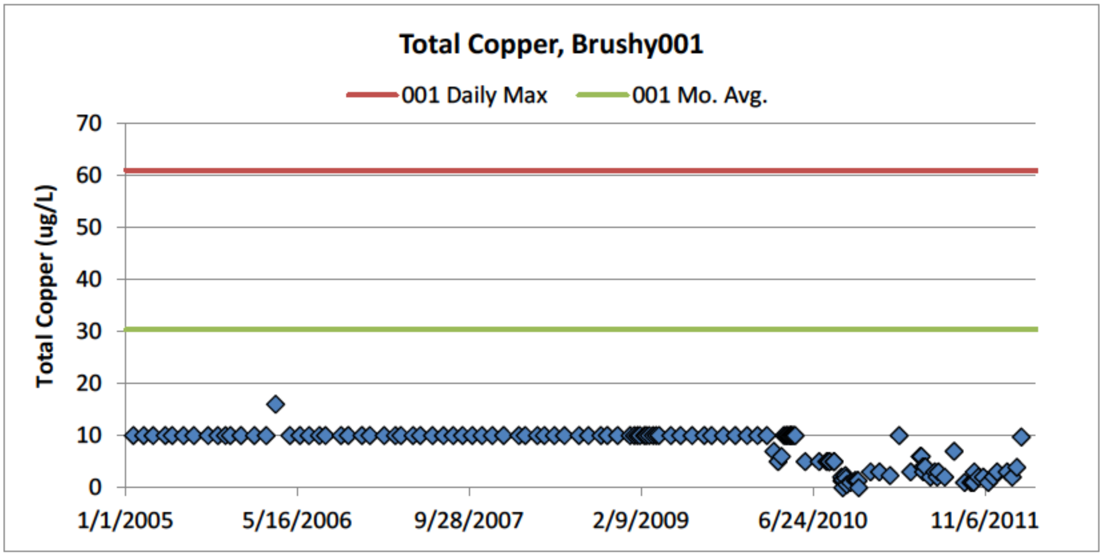


Figure 3-3. Time Series Plot for Total Copper at Brushy001

Total lead effluent data are shown in Figure 3-4 for outfall 001, between January 2005 and February 2012. At outfall 001, 135 samples (98%) were higher than both the future final daily maximum and future final monthly average limits.

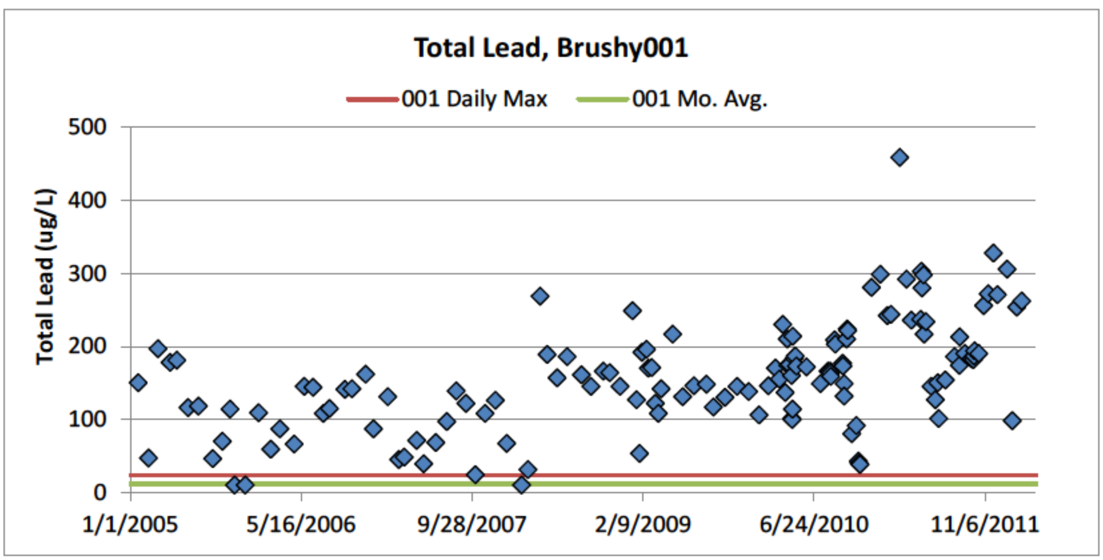


Figure 3-4. Time Series Plot for Total Lead at Brushy001

Figure 3-5 shows total zinc concentrations at outfall 001 between January 2005 and February 2012. Most samples (89%) were higher than both the future final daily maximum and future final monthly average limits for this time period. Nine samples (6%) were lower than the future final monthly average limit.

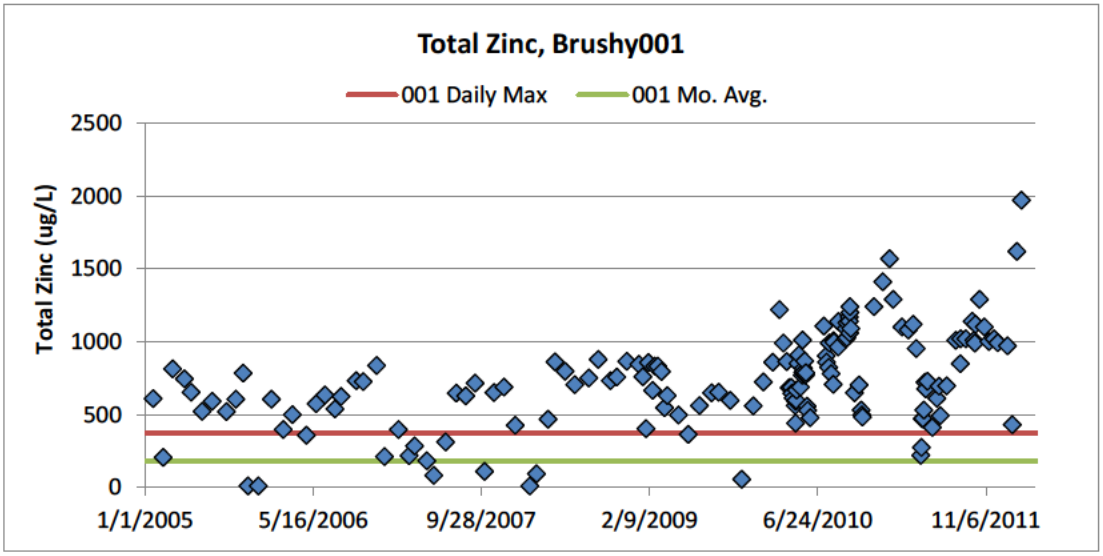


Figure 3-5. Time Series Plot for Total Zinc at Brushy001

TSS concentrations measured at outfall 001 between January 2005 and February 2012 are shown in Figure 3-6. During this monitoring period, only one sample was higher than the existing interim and future final monthly average (20 mg/L) and future final daily maximum (30 mg/L) MSOP effluent limits for TSS at Outfall 001; the rest of the data were all below the limits for TSS.

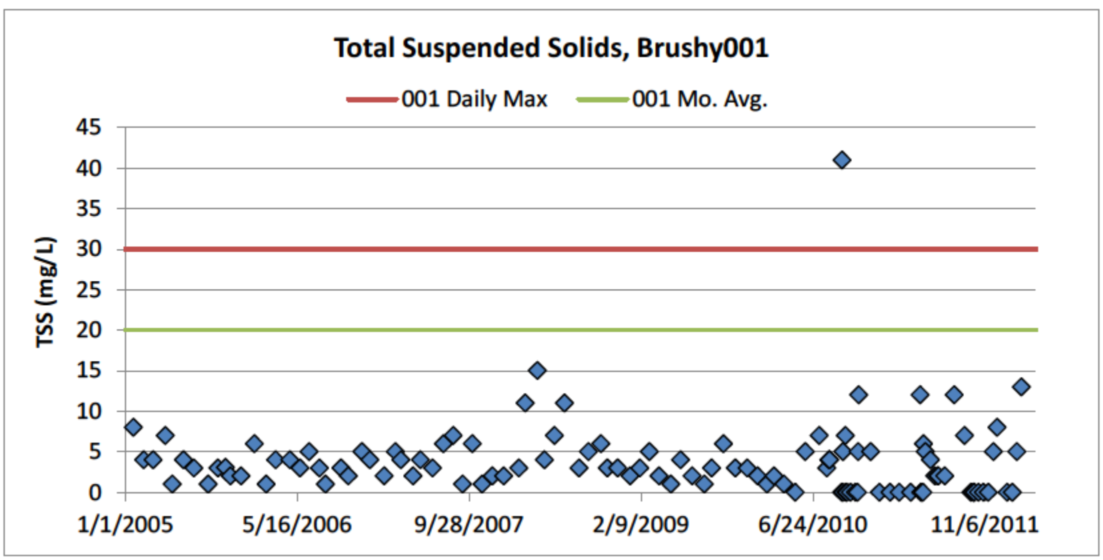


Figure 3-6. Time Series Plot for TSS at Brushy001

Table 3-4 summarizes the data presented in the preceding section, in terms of the number of samples and percent of samples exceeding future final MSOP limits for outfall 001.

Table 3-4. Summary of Samples Higher Than Future Final MSOP Limit for Brushy Creek Outfall 001.

Parameter	Total Samples	Monthly Avg Limit		Daily Max Limit	
		# Samples	% of Samples	# Samples	% of Samples
Tot-Cd	51*	50	98%	30	59%
Tot-Cu	134	0	0%	0	0%
Tot-Pb	138	135	98%	135	98%
Tot-Zn	159	151	95%	142	89%
TSS	114	1	1%	1	1%

*Only includes samples in June 2010 and later

3.2.1.b Probability Plots for Brushy Creek Outfall Data

Probability plots were developed for the Brushy Creek outfall data to provide an alternate tool for evaluation of future final effluent limits attainment, using the effluent probability method (USEPA, 2009). These plots present rank-based cumulative probabilities of the outfall data with future final MSOP effluent limits included as vertical lines to facilitate comparison of data to the limits. The probability plots presented here reflect existing conditions and represent a possible indication of future conditions, if no action is taken to reduce metals loading to the mine water basin outfalls.

The probability plot for total cadmium for outfall 001 is presented in Figure 3-7. As previously described, only data for the period of June 2010 to January 2012 were plotted for total cadmium because prior to June 2010, a detection limit of 5-10 µg/L was used for cadmium, resulting in numerous non-detect samples. Based on these historical data, the probability of meeting the future final monthly average limit for total cadmium is about 1% at the outfall if nothing further is done to reduce metals in the discharge.

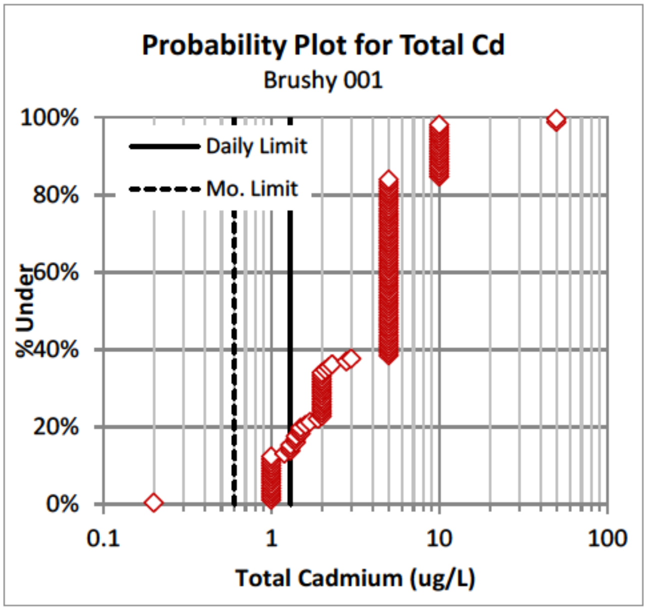


Figure 3-7. Probability Plot for Total Cadmium, Brushy001.

Figure 3-8 presents the probability plot for total copper for outfall 001. The probability plot for total copper demonstrates that 100% of samples at outfall 001 were in compliance with the MSOP future final effluent limits for total copper.

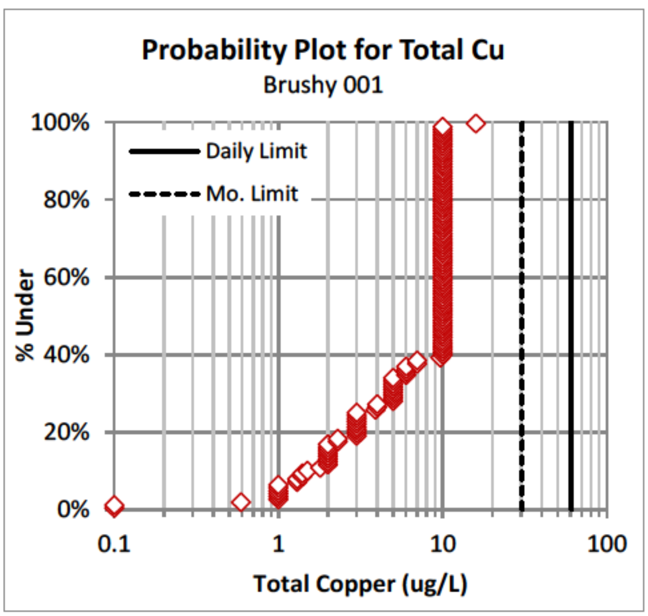


Figure 3-8. Probability Plot for Total Copper, Brushy001.

Figure 3-9 presents the probability plot for total lead for outfall 001. This plot shows that the probability of total lead in the effluent meeting future final MSOP limits is less than 5% at outfall 001 if nothing further is done to reduce metals in the discharge.

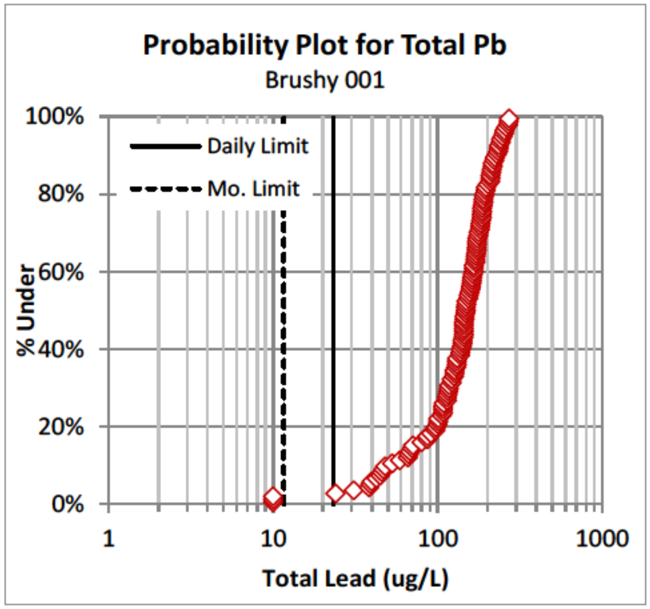


Figure 3-9. Probability Plot for Total Lead, Brushy001.

The probability plot for total zinc at outfall 001 is presented in Figure 3-10. This plot indicates that the probability of effluent attaining the future final MSOP limits for total zinc at outfall 001, based on these historical data, is about 10% or less if nothing further is done to reduce metals in the discharge.

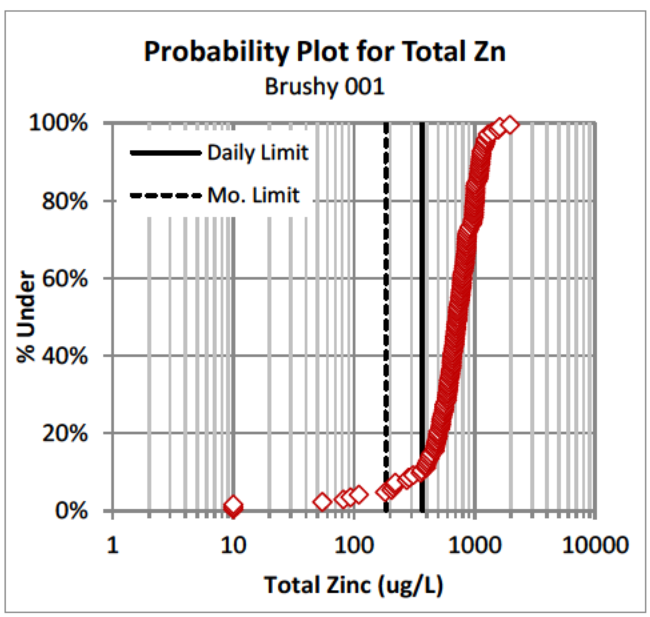


Figure 3-10. Probability Plot for Total Zinc, Brushy001.

These analyses suggest that cadmium, lead and zinc are less likely than copper to attain their respective future final MSOP limits, assuming no additional treatment, and are therefore a higher control priority at Brushy Creek.

In addition to concentrations of metals at the Brushy Creek outfall that are higher than the future final MSOP limits, effluent from the Brushy Creek outfall 001 has historically failed to pass chronic whole effluent toxicity (WET) tests. Concentrations of cadmium, zinc, and lead exceed water quality criteria. Given the elevated concentrations of metals, it is hypothesized that measures which result in reduced metals concentrations positively impact the results of the chronic WET tests.

3.2.2 Seasonal Variability of Metals at Outfall

The Brushy Creek outfall data were grouped by month for each metal to provide a graphical way to observe seasonal variations in the data. Box-and-whisker plots ("box plots") were prepared to show variation from month to month[5]. The future final MSOP limits are provided for comparison with the data.

Figure 3-11 shows a monthly box plot for measured total cadmium concentrations at outfall 001. The utility of the plot is limited due to the high number of non-detect samples (prior to June 2010, higher detection limits of 5 µg/L and 10 µg/L were used). However, there is insufficient data between June 2010 and February 2012 to construct monthly box plots for total cadmium, so the entire dataset was used.

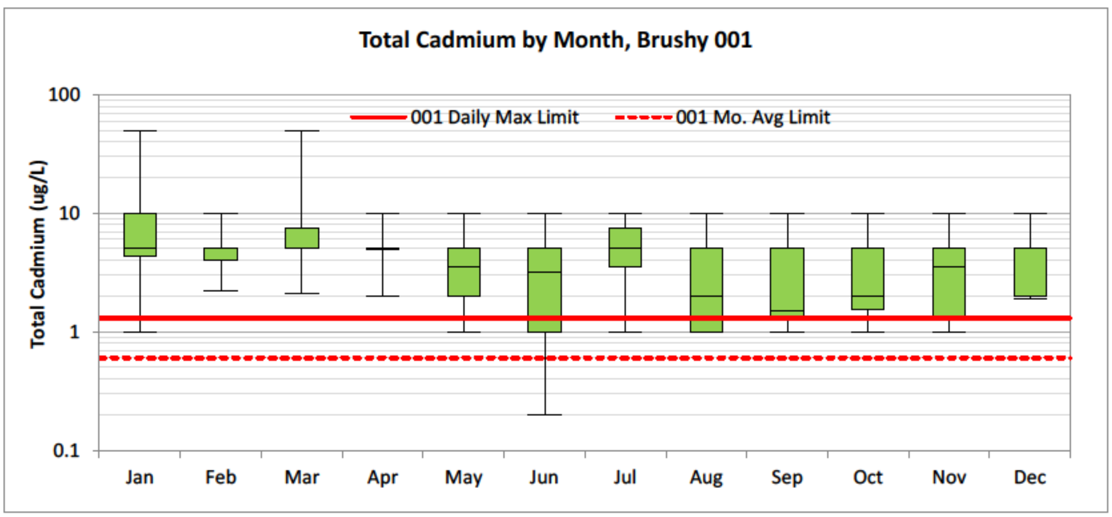


Figure 3-11. Monthly Box Plot for Total Cadmium at Brushy001.

Due to the high number of non-detect values and the low range of values measured, it is not possible to draw any conclusions about seasonal variability of total cadmium from these data.

[5] Box plots depict the median effluent concentrations, along with the upper and lower quartiles (top and bottom of box, respectively) and the minimum and maximum recorded values (upper and lower ends of whiskers).

The monthly box plot for total copper at outfall 001 is presented in Figure 3-12. There appears to be little monthly variation in total copper at outfall 001.

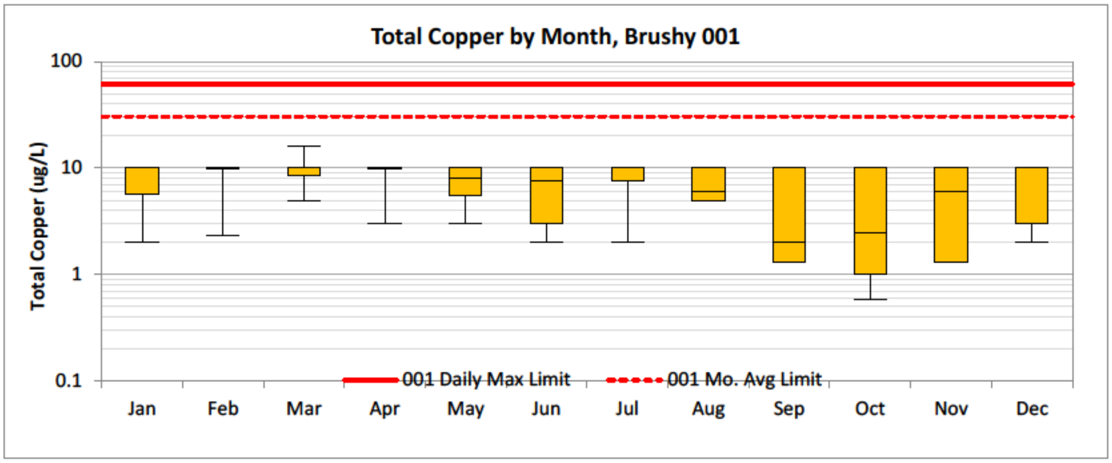


Figure 3-12. Monthly Box Plot for Total Copper at Brushy001.

The monthly box plot for total lead at outfall 001 is presented in Figure 3-13. Although the data appear to be somewhat lower during the summer months, there does not appear to be a strong seasonal pattern.

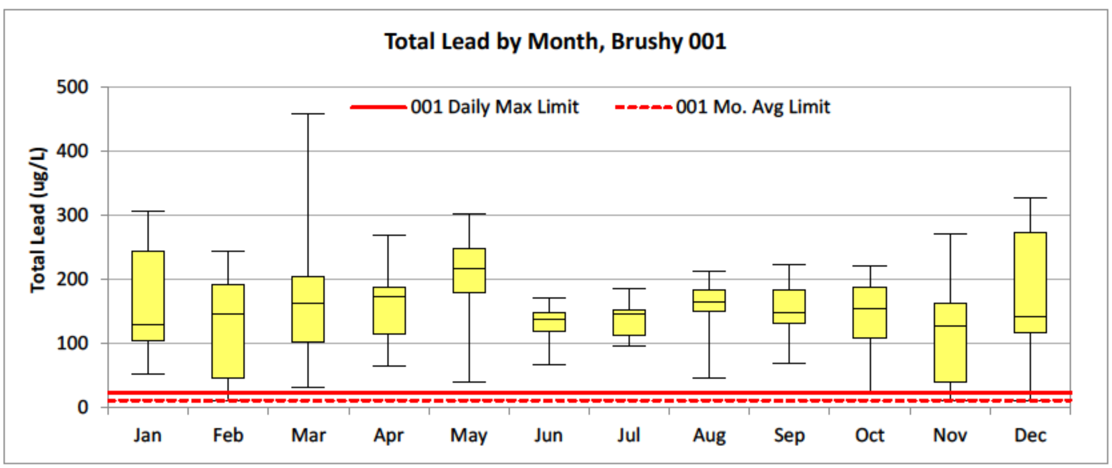


Figure 3-13. Monthly Box Plot for Total Lead at Brushy001.

Figure 3-14 presents the monthly box plot for total zinc at outfall 001. As with other metals, these data do not suggest a strong pattern of seasonal variation.

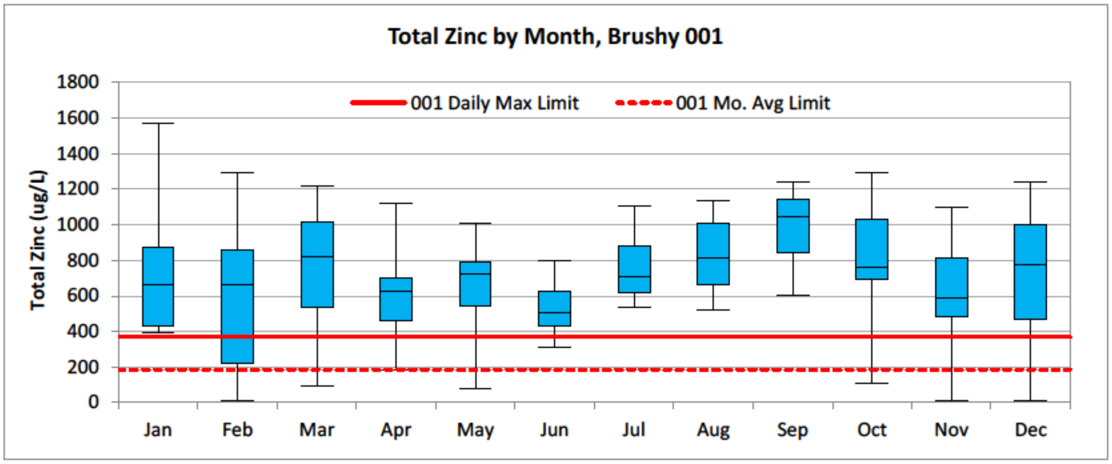


Figure 3-14. Monthly Box Plots for Total Zinc at Brushy001.

3.2.3 Comparison of Dissolved Metals to Total Metals

In evaluating the potential for attainment of future final MSOP limits and potential measures to control metals in effluent, it is important to understand the relationship between dissolved and total metals. For purposes of this SWMP, this was accomplished by adding dissolved metals results to the probability plots presented in Section 3.2.1.b. This approach allows a visual qualitative determination of whether attainment is significantly influenced by metals in the dissolved phase, as opposed to metals associated with suspended solids.

Figure 3-15 shows the probability plot for total and dissolved cadmium for outfall 001. The distributions for dissolved and total cadmium are very similar and there does not appear to be a significant difference between them with respect to the probability of meeting both future final daily and future final monthly limits. This indicates that control of both solid and dissolved phase cadmium is important in attaining future final MSOP limits at Brushy Creek.

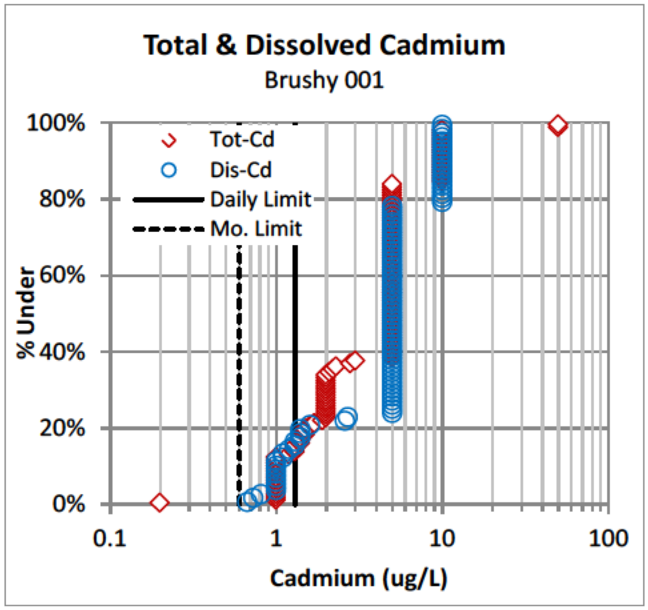


Figure 3-15. Probability Plots for Total and Dissolved Cadmium, Brushy001.

The probability plot for total and dissolved copper for outfall 001 is shown in Figure 3-16.

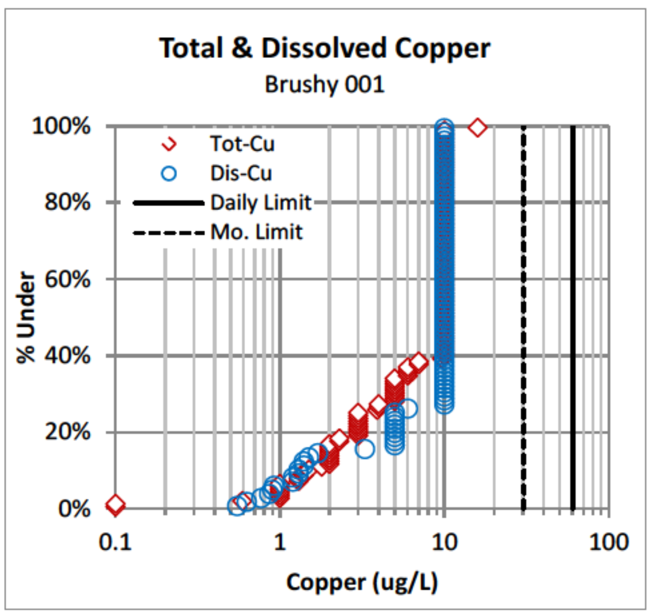


Figure 3-16. Probability Plot for Total and Dissolved Copper, Brushy001.

As with cadmium, the distributions for dissolved and total copper are very similar and there does not appear to be a significant difference between them with respect to the probability of meeting both future final daily and future final monthly limits. It does not appear that control of either total or dissolved copper at Brushy Creek is a significant issue.

Figure 3-17 shows the probability plot for total and dissolved lead for outfall 001.

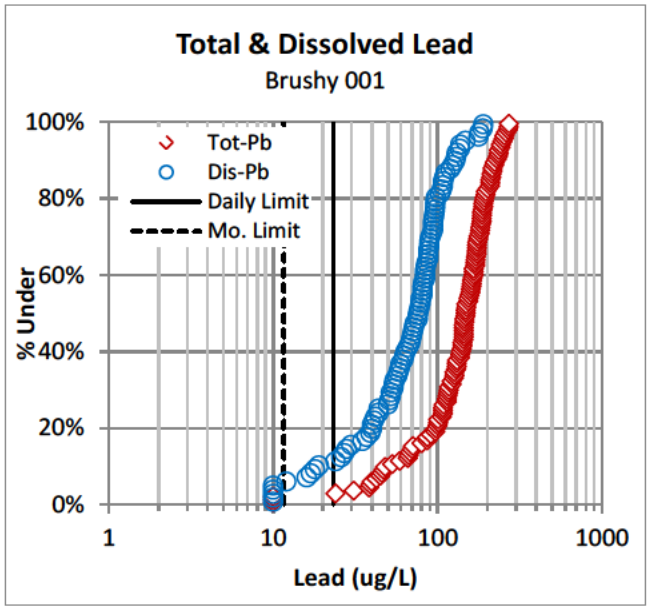


Figure 3-17. Probability Plot for Total and Dissolved Lead, Brushy001.

The distribution for dissolved lead is well separated from the total lead distribution, but the probability of dissolved lead meeting either the future final daily and future final monthly limits is relatively low, suggesting that control of both dissolved and total at Brushy Creek is important for attaining future limits.

The probability plots for total and dissolved zinc for outfall 001 are shown in Figure 3-18. The distributions for dissolved and total zinc are very similar and both fall above the future final MSOP limits most of the time. These results indicate that both dissolved and total zinc require control to meet the future final MSOP limits at Brushy Creek.

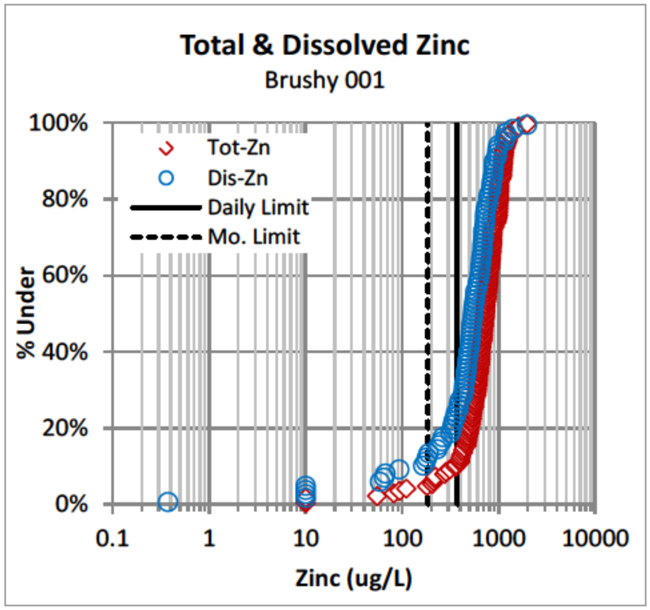


Figure 3-18. Probability Plot for Total and Dissolved Zinc, Brushy001.

3.3 SOURCES OF METALS LOADING TO OUTFALLS

As described previously in section 2.1, there are two major sources of flow to the mine water basin outfall at the Brushy Creek facility:

- Mine Water
- Stormwater (including direct runoff to the basin and excess water pumped from the tailings impoundment)

Each of these flows also carries a metals load to the basin. These loads, as well as their relative importance to effluent quality, are discussed below.

3.3.1 Mine Water

As described in Section 2.1.2, mine water is pumped to the surface at the Brushy Creek mine water box under normal operating conditions and flows to the mine water basin from there. Thirteen samples of influent mine water were collected at the mine water box for use in characterizing mine water for this evaluation (sample location MWBox). The data from these samples represent the mine water quality coming from the main mine water sump in Brushy Creek Mine. Box plots of the total and dissolved metals at MWBox are presented in Figure 3-19 through Figure 3-22 for cadmium, copper, lead and zinc.

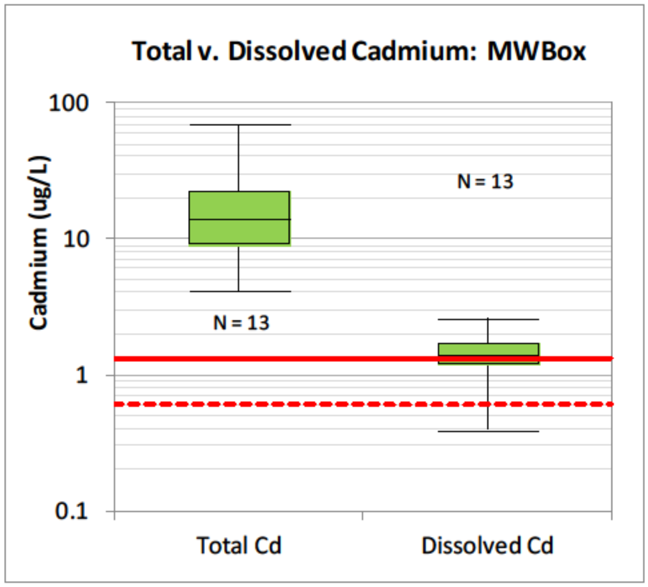


Figure 3-19. Box Plots Comparing Total and Dissolved Cadmium in Influent to the Brushy Creek Mine Water Basin.

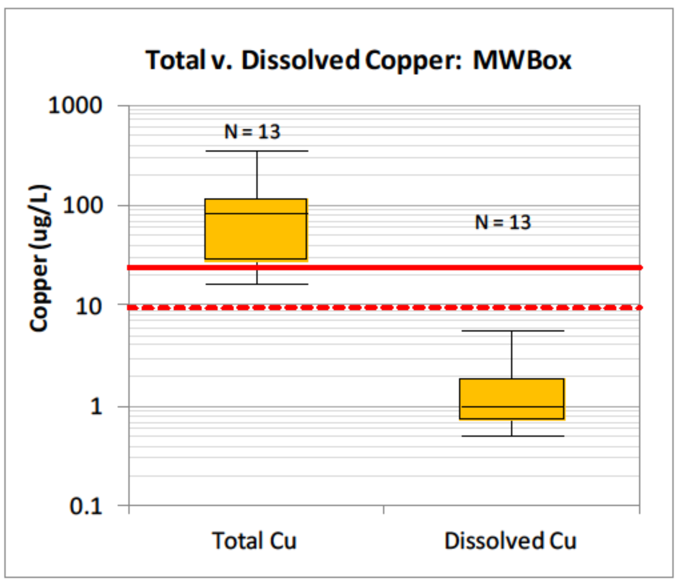


Figure 3-20. Box Plots Comparing Total and Dissolved Copper in Influent to the Brushy Creek Mine Water Basin.

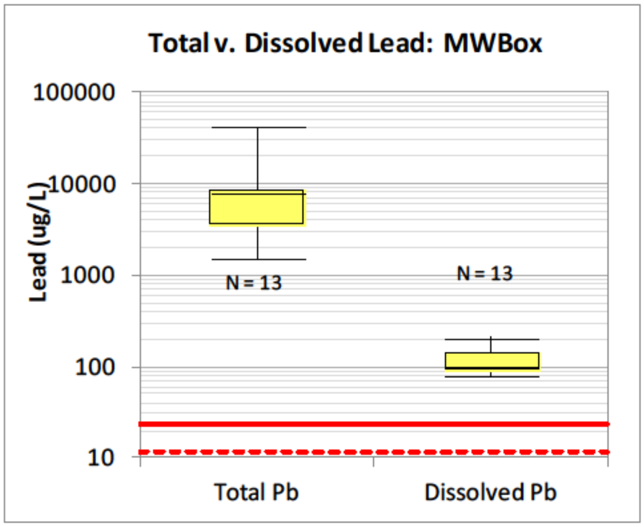


Figure 3-21. Box Plots Comparing Total and Dissolved Lead in Influent to the Brushy Creek Mine Water Basin.

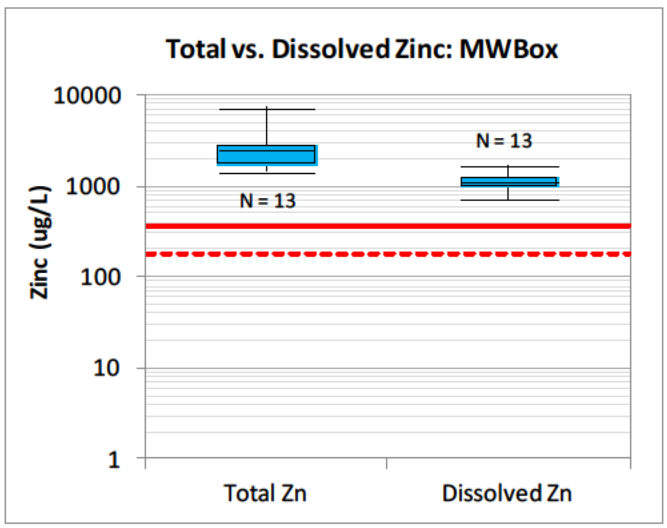


Figure 3-22. Box Plots Comparing Total and Dissolved Zinc in Influent to the Brushy Creek Mine Water Basin.

These data support the following observations:

- Results for all incoming mine water samples are higher than both the future final daily maximum and future final monthly average MSOP limits for cadmium, lead and zinc.
- Results for most incoming mine water samples are higher than both the future final daily maximum and future final monthly average MSOP limits for copper.

- All dissolved lead and zinc results in incoming mine water samples are higher than their respective future final daily maximum and future final monthly average MSOP limits.

The fact that dissolved results for lead and zinc are higher than their respective limits may indicate that removal of dissolved lead and zinc must occur in order to attain future final MSOP limits. The average, minimum and maximum concentrations of total metals in influent mine water for the mine water basin are summarized in Table 3-5.

Table 3-5. Average, Minimum and Maximum Concentrations of Total Metals in Mine Water Basin Influent at Brushy Creek.

Parameter	Units	Avg. Concentration	Min. Concentration	Max. Concentration
Total Cadmium	µg/L	19.3	4.2	70.7
Total Copper	µg/L	110.1	16.7	344
Total Lead	µg/L	10,290	1,510	41,500
Total Zinc	µg/L	2,975	1,434	7,330

Average metals loading rates to the mine water basin from mine water were calculated using the average concentrations in Table 3-7 and the average mine water flows discussed in Section 2.2. These calculated average loads can serve as a point of comparison for other potential sources of metals loading, including stormwater runoff and truck wash water. The average calculated loads are presented in Table 3-6.

Table 3-6. Average Calculated Metals Loads in Mine Water at Brushy Creek.

Metal	Average Load to Mine Water Basin from Mine Water (kg/yr)
Cadmium	88.3
Copper	504
Lead	47,088
Zinc	13,614

3.3.2 Stormwater

As noted in Section 2.1.5, significant volumes of stormwater enter the Brushy Creek tailings impoundment and mine water basin annually. Although no stormwater runoff samples have been collected at Brushy Creek, the metals loading to the mine water basin can be estimated using median concentrations from the National Stormwater

Quality Database (NSQD, version 1.1)[6], which is available on-line. That database is a compilation of thousands of measurements and the results were evaluated by land use. The land use surrounding the Brushy Creek mine water basin and tailings impoundment is forested and the NSQD does not provide results specifically for forested land, it does provide results for undeveloped “open space”. Table 3-7 presents the median concentrations of total cadmium, copper, lead and zinc in stormwater runoff from open space, based on the NSQD, along with the estimate annual loading to the mine water basin and tailings impoundment, based on these concentrations and the annual stormwater flows presented in Section 2.1.5.

Table 3-7. Estimated Metals Loads to Mine Water Basin and Tailings Impoundment at Brushy Creek from Stormwater.

Metal	Median Estimated Concentration in Stormwater Runoff (μg/L)	Average Stormwater Load to Mine Water Basin (kg/yr)
Cadmium	0.38	0.11
Copper	10	2.98
Lead	10	2.98
Zinc	88	26.3

3.3.3 Truck Wash

The influent to the Brushy Creek mill reservoir from the truck wash was evaluated to assess the relative impact of truck wash on water quality at mine water outfall 001. Two samples of truck wash discharge were collected (12/9/10 and 5/17/11). These results were compared to the incoming mine water for those dates to assess the relative concentrations of metals. These results are presented in Table 3-8 and depicted graphically in Figure 3-23.

Table 3-8. Concurrent Sampling Results for Truck Wash and Mine Water Locations.

		12/9/10		5/17/2011	
Parameter	Units	MWBox	TWEff	MWBox	TWEff
Total Cadmium	μg/L	22.65	13.1	4.2	4.9
Total Copper	μg/L	103.35	164	27.4	56.4
Total Lead	μg/L	8910	9620	2997	4470
Total Zinc	μg/L	3310	2020	1462	1342

[6] http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/Mainms4paper.html

Tot. Susp. Solids	mg/L	166.5	57	78	376

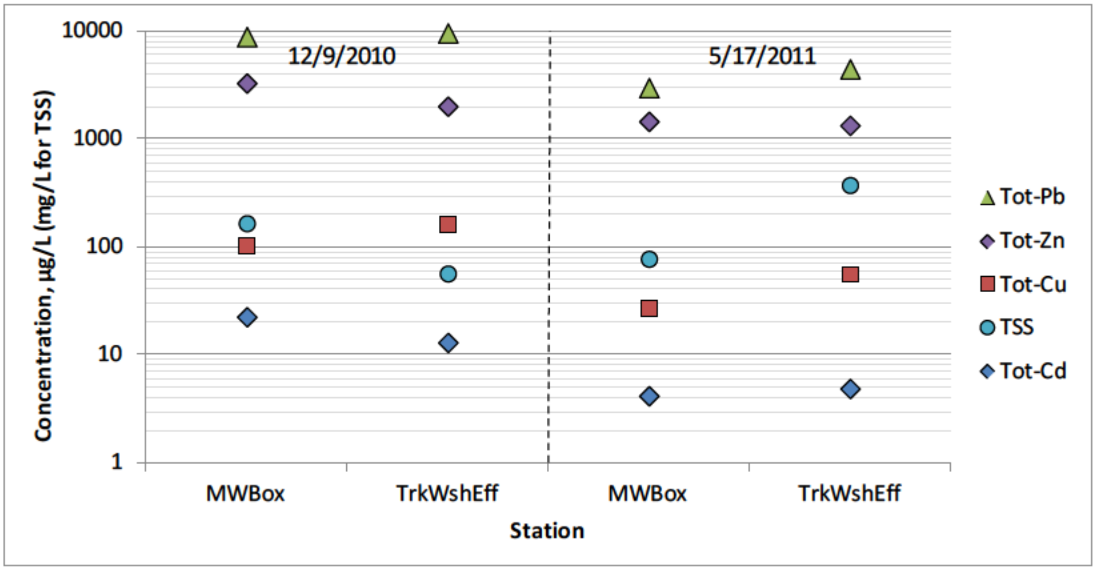


Figure 3-23. Sampling Results for Total Metals and Solids in Truck Wash Discharge and Mine Water.

The truck wash discharge data can be used in conjunction with the flow estimates developed in Section 2.1.6, to calculate metals loading estimates for the Brushy Creek truck wash. These estimates are presented in Table 3-9. Comparison of the truck wash load estimates in Table 3-9 with the load estimates for mine water presented in Table 3-6, it is apparent that mine water contributes a significantly higher load of metals than the truck wash.

Table 3-9. Average Metals Loads to Brushy Creek Mine Water Basin from the Truck Wash.

Metal	Average Load to Mine Water Basin 003 from Truck Wash (kg/yr)
Cadmium	0.1
Copper	1.3
Lead	81.3
Zinc	19.4

It should also be noted that the results shown in Figure 3-23 indicate that truck wash discharge closely resembles incoming mine water with respect to total metals concentrations. This is a further indication that the truck wash does not significantly impact water quality at the outfall.

3.3.4 Tailings Impoundment Water

As discussed in Section 2.1.5, the Brushy Creek MSOP allows Doe Run to pump excess water from the tailings impoundment to the mine water basin to avoid overtopping the emergency spillway on the tailings dam. When necessary, excess water is pumped to the mine water basin from a barge pump located in the tailings impoundment. Although this is a very rare occurrence, it may be a potential source of metals loading to the mine water basin. Water in the tailings impoundment was sampled adjacent to the barge pump to characterize the quality of the water that would be pumped to the mine water basin. The results are compared to mine water data for total cadmium, total copper, total lead, and total zinc in Figures 3-24, 3-25, 3-26, and 3-27, respectively.

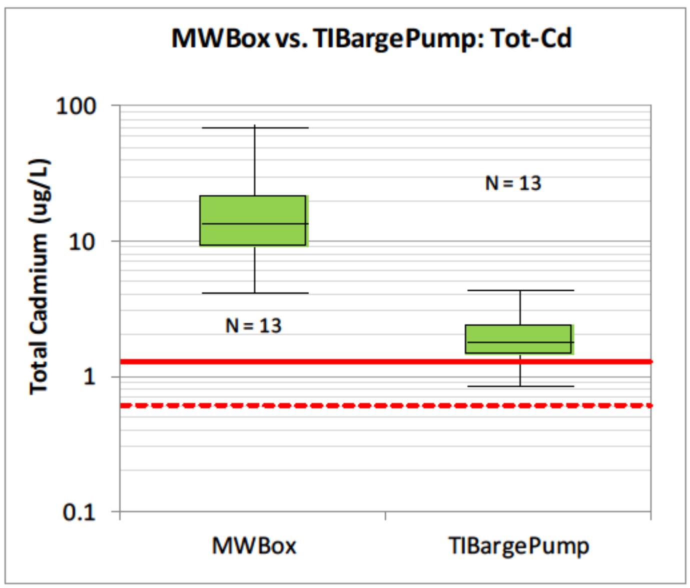


Figure 3-24. Box Plots Comparing Total Cadmium in Mine Water to Tailings Impoundment Water.

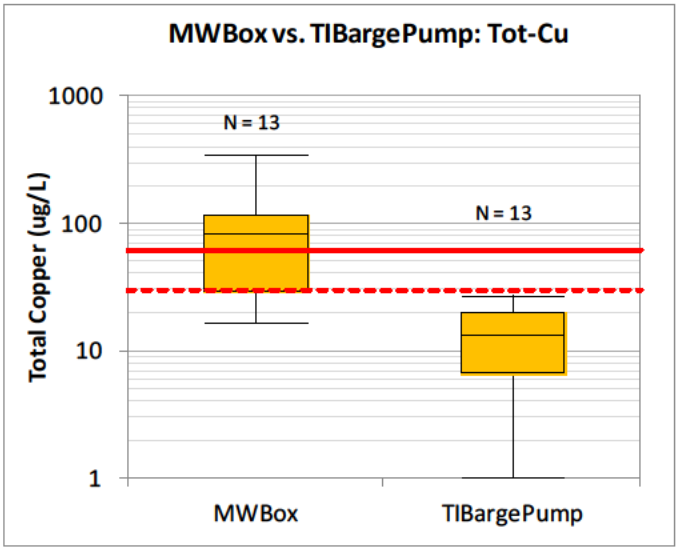


Figure 3-25. Box Plots Comparing Total Copper in Mine Water to Tailings Impoundment Water.

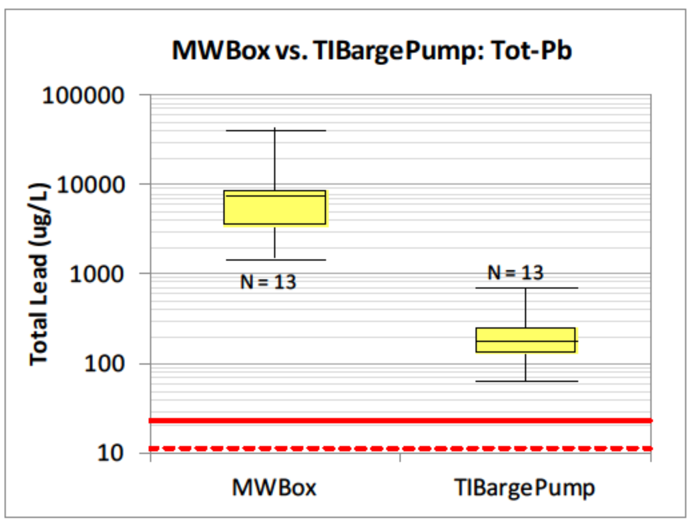


Figure 3-26. Box Plots Comparing Total Lead in Mine Water to Tailings Impoundment Water.

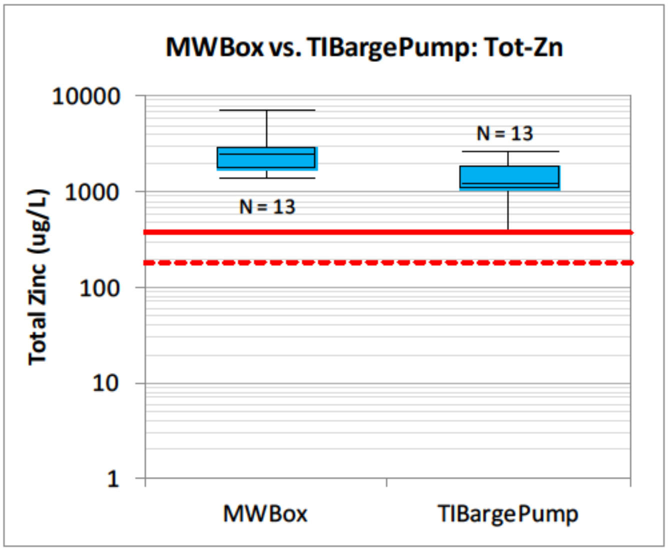


Figure 3-27. Box Plots Comparing Total Zinc in Mine Water to Tailings Impoundment Water.

The data presented in the plots above indicate that the tailings impoundment water has lower concentrations of total cadmium, copper and lead than the incoming mine water. There does not appear to be a significant difference in the concentration of total zinc between the two sampling locations.

Typical volumes of excess water pumped to the mine water basin from the tailings impoundment at Brushy Creek were estimated from pumping records at Brushy Creek. These estimates were then used in conjunction with average metals concentrations to generate the loading estimates presented in Table 3-10.

Table 3-10. Average Metals Loads to the Brushy Creek Mine Water Basin from Excess Water Pumped from the Tailings Impoundment.

Metal	Average Load to Mine Water Basin from Tailings Impoundment (kg/yr)
Cadmium	0.5
Copper	3
Lead	52
Zinc	335

3.4 SOURCE ASSESSMENT SUMMARY

There are four major sources of target metals to the Brushy Creek mine water basin and, subsequently, to surface waters via the mine water basin outfall: mine water, stormwater runoff, truck wash water and excess water pumped from the tailings impoundment. The overall findings of the source assessment of metals to the mine water basin (and outfall 001), based on the data evaluations presented in the preceding sections, are summarized below.

- Mine water is the largest source of metals loading to the mine water basin, accounting for 67% to 98% of the total metal load, depending on the metal.
- It is unlikely that reduction of metals concentrations in stormwater runoff, truck wash water and excess water pumped from the tailings impoundment will have a significant effect on water quality at outfall 001.

Figures 3-28 through 3-31 show the relative distributions of these sources to the Brushy Creek mine water basin for total cadmium, total copper, total lead, and total zinc.

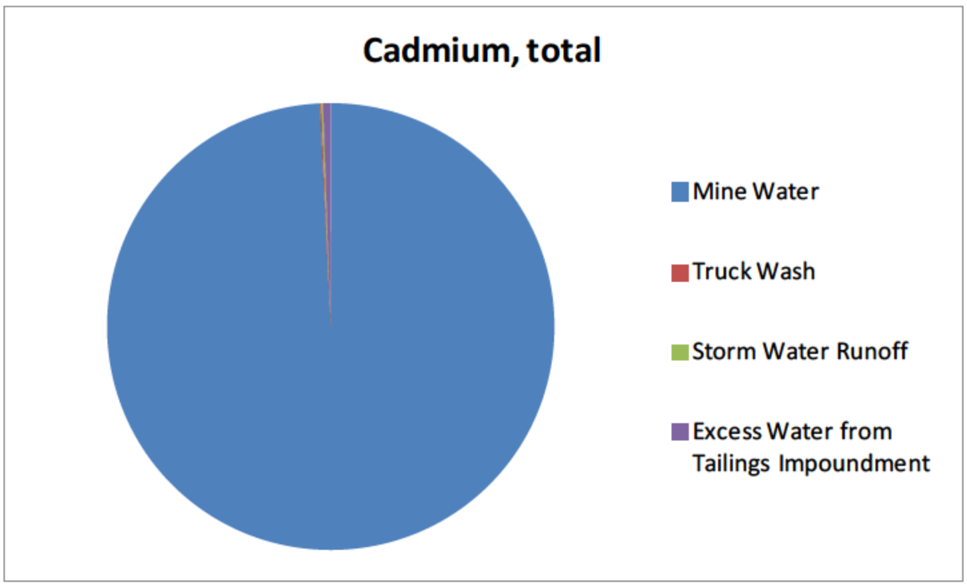


Figure 3-28. Relative Distribution of Total Cadmium Load Sources to the Brushy Creek Mine Water Basin.

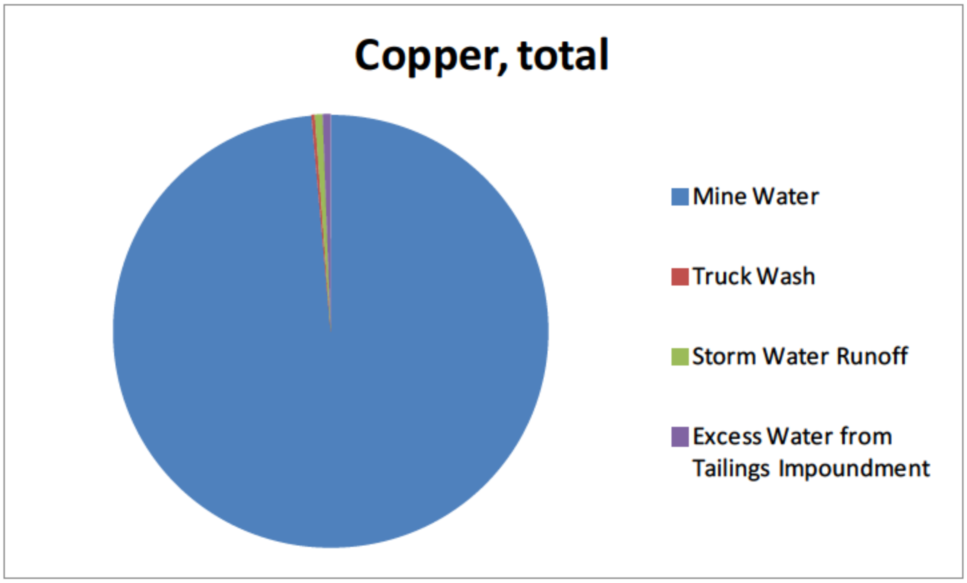


Figure 3-29. Relative Distribution of Total Copper Load Sources to the Brushy Creek Mine Water Basin.

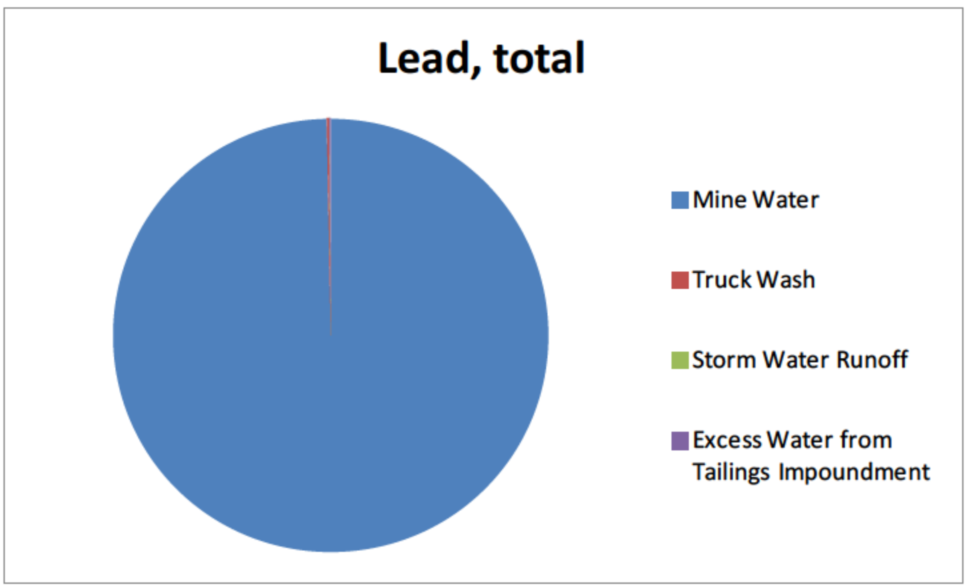


Figure 3-30. Relative Distribution of Total Lead Load Sources to the Brushy Creek Mine Water Basin.

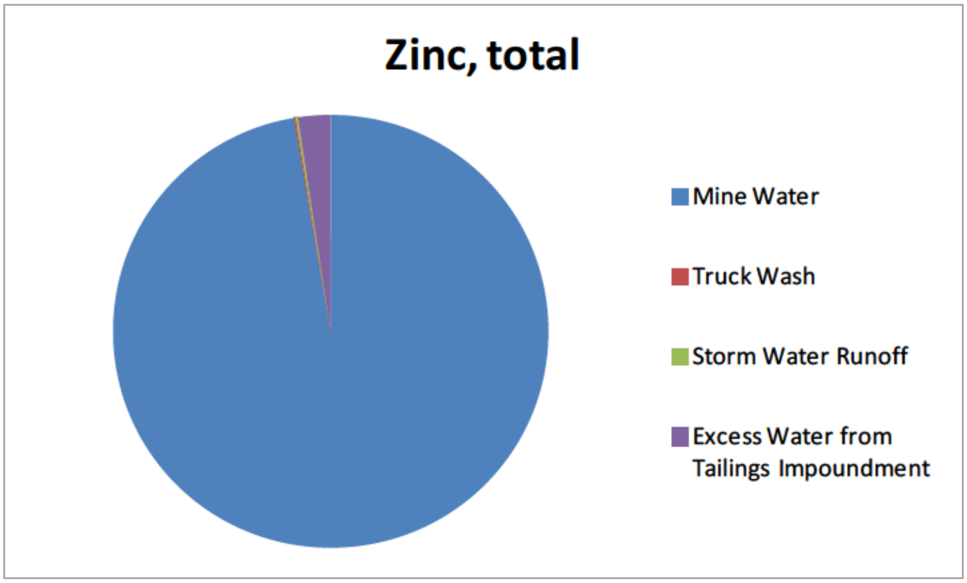


Figure 3-31. Relative Distribution of Total Zinc Load Sources to the Brushy Creek Mine Water Basin.

Because mine water is the dominant source of metals loading to the mine water basin, further significant reduction in metals concentrations at the outfall can likely be achieved only by improving the level of water treatment before mine water reaches the mine water basin, within the mine water basin, or between the mine water basin and outfall 001.

4. FATE AND TRANSPORT EVALUATION

To understand and evaluate potential control measures for reducing metals concentrations at the Brushy Creek facility permitted outfalls, it is necessary to define the major fate and transport processes that affect metals in water before it reaches the outfalls. This section of the SWMP identifies the significant fate and transport processes affecting water quality at the outfalls and provides an evaluation of those processes to support identification of control measures.

4.1 IDENTIFICATION OF POTENTIAL FATE AND TRANSPORT PROCESSES AFFECTING OUTFALL WATER QUALITY AT BRUSHY CREEK

As stated in Section 3 of this plan, mine water is the major source of metals loading to outfalls 001 and loading from other sources (stormwater runoff and truck wash water) appears to have little or no effect on effluent quality from the mine water basin. Therefore, the goal of meeting future final MSOP limits at the Brushy Creek facility must be met by reducing metals concentrations in mine water. At Brushy Creek, mine water is pumped to the surface and discharged into the mine water basin. This being the case, the fate and transport processes that affect metals in mine water before discharge are the processes within the mine water basin itself, including the following:

- Solids settling – Metals already complexed with suspended solids can settle out of suspension. This process would result in a decrease in metals concentration between the mine water influent and the outfall, accompanied by a decrease in TSS between these locations.
- Solids resuspension – This is the opposite of settling; solids on the bed of the basin are resuspended into the water column by hydrodynamic or wind-driven energy.
- Adsorption to solids – Metals can be adsorbed to solids on the bed of the basin or to organic (algal) solids in the water column. This would result in a decrease in dissolved metals concentrations between the mine water influent and the outfall.

4.2 EVALUATION OF POTENTIAL FATE AND TRANSPORT PROCESSES AFFECTING METALS AT THE BRUSHY CREEK MINE WATER OUTFALL

The potential fate and transport processes for metals in the Brushy Creek mine water basin, identified in Section 4.1, are evaluated below.

4.2.1 Solids Settling in Mine Water Basin

Settling of suspended solids in the mine water basin will reduce TSS and potentially reduce total metals concentrations at the outfall if significant metals are associated with the TSS. To evaluate whether this process is currently occurring in the Brushy

Creek mine water basin, box plots were constructed to evaluate whether total metals and solids concentrations appear to decrease within the mine water basin between their inlet and outlet. Data from sampling station MWBox represents mine water entering the basin. These data are compared to the outfall data from station Brushy001.

Box plots for total cadmium[7], copper, lead, zinc and TSS at the mine water basin inlet and outlet are presented in Figure 4-1 through Figure 4-5. MSOP effluent limits are included in the plots to facilitate comparison of effluent concentrations with applicable effluent standards.

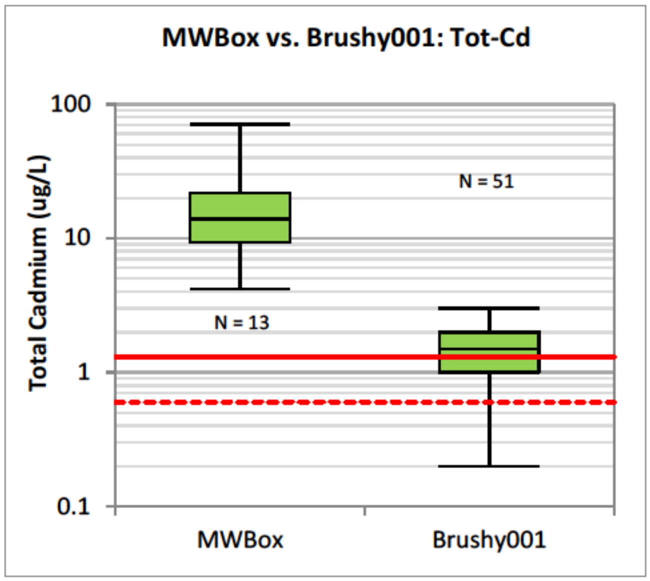


Figure 4-1. Comparison of Total Cadmium Concentration Entering and Leaving Brushy Creek Mine Water Basin

[7] As discussed previously, the total cadmium plots use data measured at the four target locations between June 2010 and January 2012. This time period was selected because prior to June 2010, detection limits of both 5 µg/L and 10 µg/L were used for cadmium. Consequently, most samples were non-detect and would not add value in comparing the data to MSOP effluent limits (all effluent limits are below 5 µg/L).

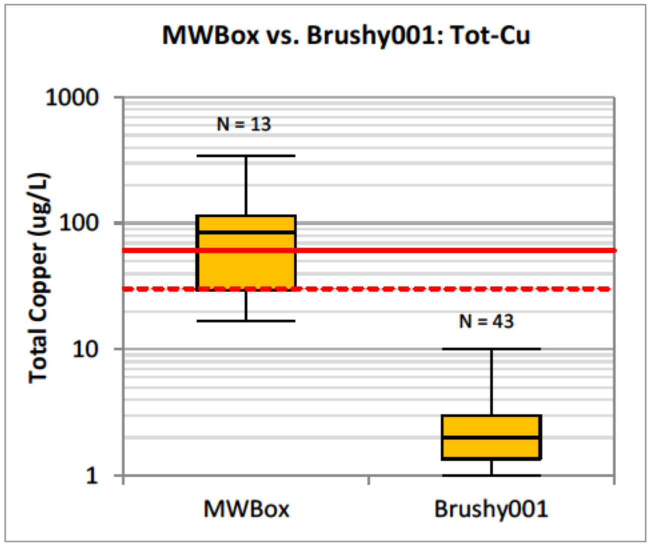


Figure 4-2. Comparison of Total Copper Concentration Entering and Leaving Brushy Creek Mine Water Basin

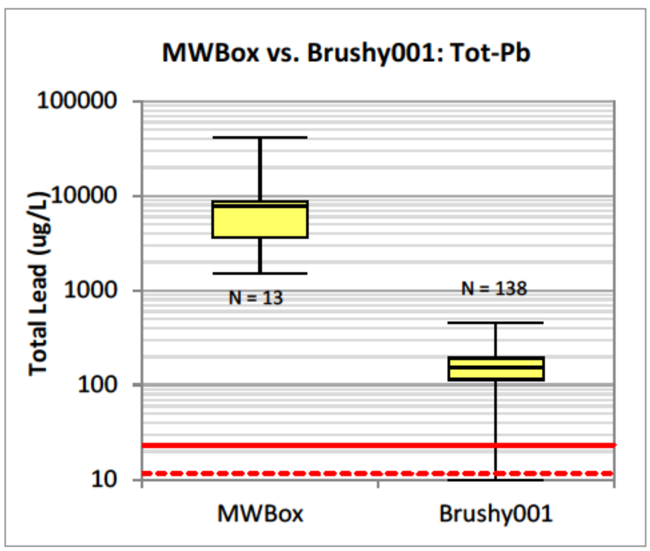


Figure 4-3. Comparison of Total Lead Concentration Entering and Leaving Brushy Creek Mine Water Basin

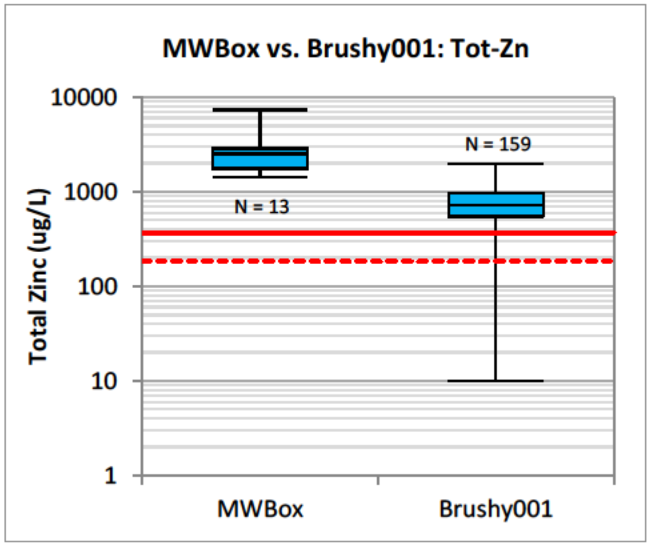


Figure 4-4. Comparison of Total Zinc Concentration Entering and Leaving Brushy Creek Mine Water Basin

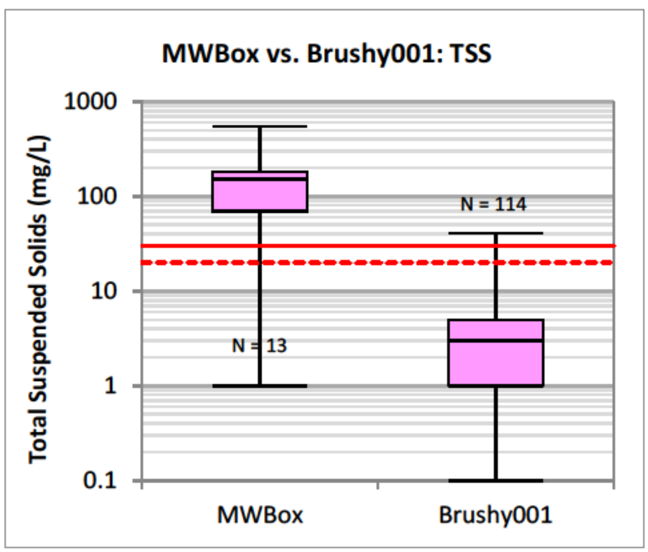


Figure 4-5. Comparison of TSS Concentration Entering and Leaving Brushy Creek Mine Water Basin

Table 4-1 summarizes the average concentrations calculated for each parameter at MW001 and Brushy001, as well as the decrease in concentration based on the change in average concentration.

Table 4-1. Change in Average Total Metals and TSS Concentrations Between Influent and Effluent in Brushy Creek Mine Water Basin.

Parameter	Units	Average Concentration		Decrease in Concentration	Percent Decrease
		MWBox	Brushy001		
Total Cadmium	µg/L	19.3	1.6	17.7	92%
Total Copper	µg/L	110.1	2.8	107.3	97%
Total Lead	µg/L	10,291	157.7	10,133.3	98%
Total Zinc	µg/L	2,975	724	2,251	76%
Total Suspended Solids	mg/L	167.5	3.7	163.8	98%

Comparing the changes in average concentrations of target parameters across the Brushy Creek mine water basin, the following observations can be made:

- Total copper, lead and TSS show the largest reduction in average concentration across the mine water basin, between 97% and 98%.
- Total zinc shows the lowest reduction in the mine water basin (76%).

These results show that the Brushy Creek mine water basin is providing significant removal of TSS and most total metals concentrations from mine water, although comparison of effluent data from outfall 001 to future final effluent limits (Section 3.2.1) indicates that this is not sufficient to meet future final effluent limits.

4.2.2 Solids Resuspension in Mine Water Basin

The surface of the Brushy Creek mine water basin is open to the atmosphere and therefore subject to turbulence caused by wind. In addition, mine water is pumped into the basin at a relatively high rate (about 2,300 gpm on average). This flow may be adequate to resuspend some of the unconsolidated sediment on the bottom of the basin. However, the very high rate of TSS removal discussed in Section 4.2.1 indicates that resuspension of solids is not an issue in the Brushy Creek mine water basin.

4.2.3 Adsorption to Soil Solids in Mine Water Basin

Adsorption of dissolved metals to solids in the Brushy Creek mine water basin is another process by which reductions in metals concentrations could potentially occur within the basin. One possibility is that dissolved metals might become adsorbed to solids on the bed of the basin. This is unlikely to occur in the mine water basin as it would require quiescent conditions and long contact times. A second possibility is that algal growth during the warm season creates organic solids in the water column to which dissolved metals become adsorbed. These organic solids then settle and the result is a reduction in dissolved metals between the inlet and outfall.

If this process is a significant one within the mine water basin, a decrease in dissolved metals concentrations between the incoming mine water and the mine water at the outfall would be expected. Box plots comparing the dissolved metals concentrations between the incoming mine water and the outfall are presented in Figures 4-6 through 4-9 for dissolved cadmium, copper, lead and zinc.

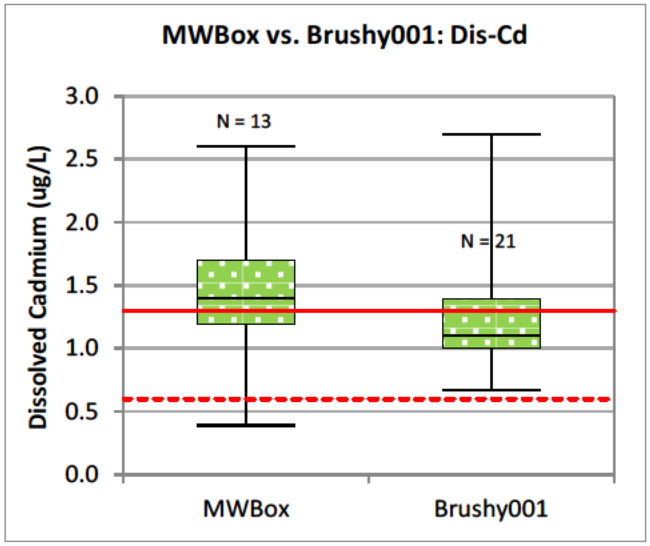


Figure 4-6. Comparison of Dissolved Cadmium Concentration Entering and Leaving Brushy Creek Mine Water Basin

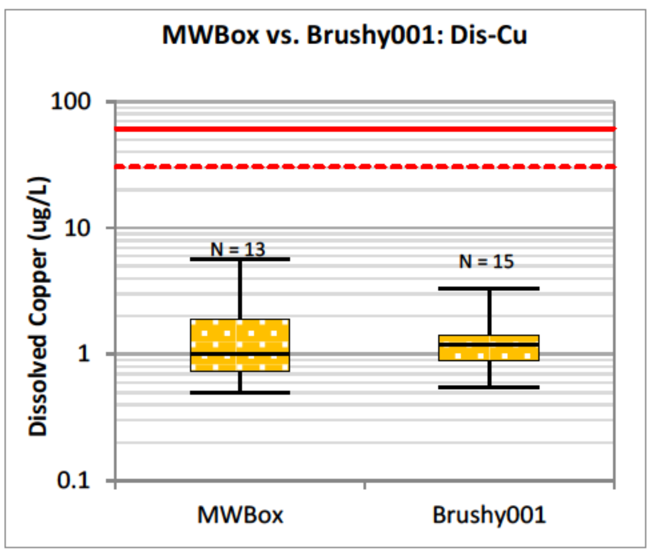


Figure 4-7. Comparison of Dissolved Copper Concentration Entering and Leaving Brushy Creek Mine Water Basin

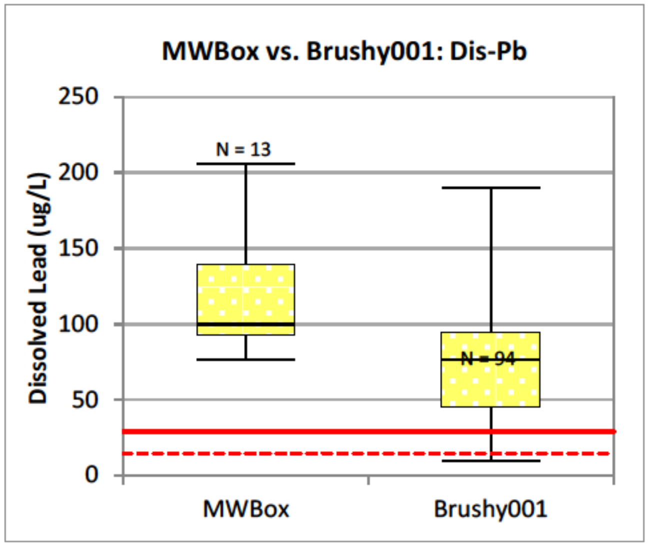


Figure 4-8. Comparison of Dissolved Lead Concentration Entering and Leaving Brushy Creek Mine Water Basin

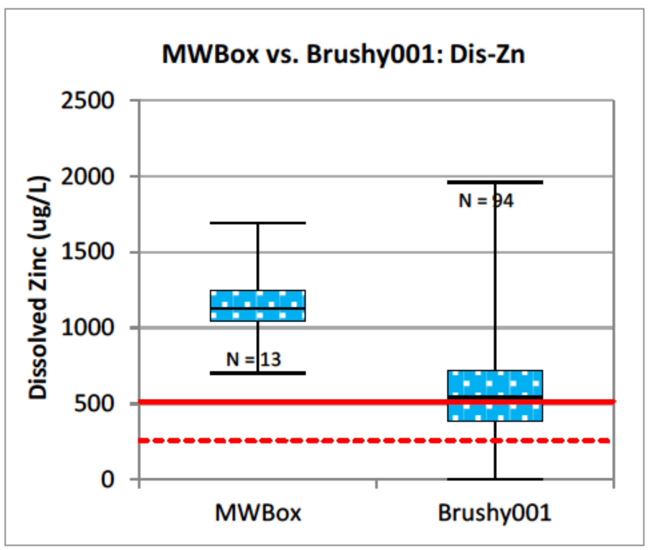


Figure 4-9. Comparison of Dissolved Zinc Concentration Entering and Leaving Brushy Creek Mine Water Basin

The comparisons of dissolved metals shown above support the following observations:

- There does not appear to be a significant decrease in dissolved cadmium or dissolved copper between incoming mine water and the outfall.
- There is a slight decrease in both the median concentration and overall range of dissolved lead between incoming mine water and the outfall.

- The most pronounced difference in median concentration between incoming mine water and the outfall is evident for dissolved zinc, however the overall range of values is not reduced between the incoming mine water and the outfall.

Based on these results, it does not appear that adsorption of dissolved metals to solids is a significant fate process affecting metals concentrations in the Brushy Creek mine water basin outfall.

4.3 FATE AND TRANSPORT PROCESS SUMMARY FOR METALS IN BRUSHY CREEK MINE WATER BASIN

The preceding analysis and discussion can be summarized by the following findings:

- The Brushy Creek mine water basin provides effective settling of TSS, which results in significant reductions of total metals.
- Resuspension of settled solids does not appear to be occurring in the Brushy Creek mine water basin.
- It does not appear that adsorption of dissolved metals to solids is a significant fate process affecting metals concentrations in the Brushy Creek mine water basin outfall.

These findings will inform the evaluation of potential water management measures for the Brushy Creek facility.

5. POTENTIAL WATER MANAGEMENT MEASURES

Potential water management issues to improve effluent quality and attain future final MSOP limits are identified in this section. As stated in the Master SWMP (LimnoTech, 2011a), a hierarchy has been established as a tool for use when water management solutions are evaluated during development of Site-Specific SWMPs. The hierarchy sets priorities for the management of regulated water at Doe Run facilities and is presented in Figure 5-1.

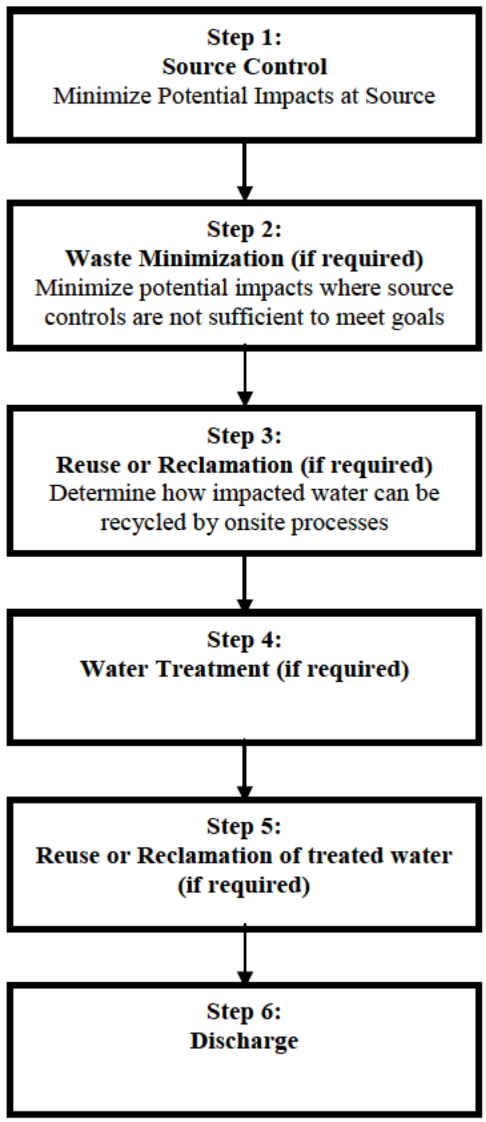


Figure 5-1. Hierarchy of Water Management Priorities

The water management hierarchy shown in Figure 5-1 establishes source control or pollution prevention through the implementation of Best Management Practices

(BMPs) as a top priority. BMPs can also support waste minimization. The hierarchy lists water treatment but in addition to treatment, the Master SWMP also states that alternative discharge practices will be evaluated. Based on this information from the Master SWMP, the identification of potential water management measures is organized as follows:

- Best management practices (source control)
- Waste minimization
- Water reuse or reclamation
- Water treatment
- Alternative discharge practices

Each of these categories of potential water management measures is discussed below.

5.1 BEST MANAGEMENT PRACTICES

The water management hierarchy places the highest priority on source control which, in the context of the Brushy Creek SWMP, means either reduction of the volume of water being discharged or the concentration of metals in the effluent from the mine water basin. The major flow volume through the mine water basin is mine water, as discussed in Section 2, and the Underground Water Management Plan for Brushy Creek Mine (LimnoTech, 2012) did not identify any significant measures to reduce mine water flows. The Brushy Creek Underground Water Management Plan did identify several BMPs to be implemented underground to minimize the concentration of metals in mine water pumped to the surface, but the effect of implementing these measures has not yet been determined. Because mine water is discharged directly to the mine water basin, there is no opportunity for BMPs at the surface to reduce mine water concentrations of metals. Any BMPs at Brushy Creek would be designed to reduce other sources of flow and/or metals to the basin.

There are two other sources of flow and metals to the Brushy Creek mine water basin, as discussed in Sections 2 and 3. These are stormwater (either direct runoff to the mine water basin or excess water pumped from the tailings impoundment) and truck wash water. However, the analyses presented in Sections 2 and 3 of this plan do not indicate that either of these sources is significant enough to affect effluent quality at present. In addition, numerous best management practices and procedures are already employed at Doe Run facilities as part of an overall stormwater management program and are discussed in the Brushy Creek Stormwater Pollution Prevention Plan (RMC, 2011). No additional practices to significantly reduce solids and metals loading the Brushy Creek mine water basin were identified for this plan.

5.2 WASTE MINIMIZATION

Waste minimization generally refers to the intentional reduction of potentially polluting by-products from industrial process that could affect water quality. At the Brushy Creek facility, the major source of metals in the effluent is the naturally occurring minerals in the Brushy Creek mine. Therefore, no opportunities for waste minimization were identified for this SWMP.

5.3 WATER REUSE OR RECLAMATION

Water reuse or reclamation can sometimes be used to reduce the total volume of effluent, thereby reducing the loading of materials to receiving waters. At Brushy Creek, process water from the mill reservoir is used in the mill and used for washing trucks, then reintroduced to the reservoir, as described in Section 2.1.6 of this plan. No other opportunities for water reclamation or reuse were identified for this SWMP.

5.4 WATER TREATMENT

Water treatment is often the last water management measure to be implemented prior to discharge. At Brushy Creek, the mine water basin is intended to provide treatment of mine water by allowing suspended solids to settle from suspension, thereby reducing TSS and total metals prior to discharge. Based on the data presented in Section 4.2.1, the mine water basin appears to be capable of reducing TSS and most total metals. However, even with high rates of solids removal, the resulting total metals concentrations at outfall 001 appear to be higher than the future final effluent limits in the Brushy Creek MSOP. Because of this, additional treatment may be required. Doe Run has recently started a series of engineering studies to evaluate mine water treatment, including the following:

- In late 2010 and early 2011, Doe Run commissioned a pilot study of coagulation/flocculation to treat metals in mine water (Barr, 2011). This study concluded that chemical precipitation could potentially reduce metals in mine water to meet future final MSOP limits.
- Also in 2011, Doe Run conducted pilot studies of biotreatment at the Sweetwater, Viburnum 29, and Buick facilities (RMC, 2012). The biotreatment technology tested was a modified version of the system that is currently in place at Doe Run's West Fork facility. The results showed that biotreatment has the potential to achieve low concentrations of target metals in mine water effluent.
- Doe Run has recently contracted for two pilot studies to further evaluate chemical precipitation for achieving future final MSOP limits. These tests are designed to verify the effectiveness of the technology and provide the basis for confident engineering design and cost estimation.

Upon completion of the pilot tests that are currently underway, Doe Run will evaluate all information developed as a result of the recent studies, determine the most effective and cost-effective treatment technology for mine water, and compare the feasibility of a new mine water treatment plant at Brushy Creek to the effectiveness and cost-effectiveness of the alternate discharge practice described in the following section.

5.5 ALTERNATIVE DISCHARGE PRACTICES

Because of the observations presented in Section 3.3.4 regarding the quality of the excess water pumped from tailings impoundment to the mine water basin, it is possible that the Brushy Creek tailings impoundment can provide even better removal of total suspended solids than the mine water basin, due to its larger volume. If this is true, then it makes sense to discharge mine water directly to the tailings impoundment and then route it to the mine water basin. Furthermore, pending the outcome of ongoing treatment pilot tests, it may be necessary to consolidate mine water and tailings water in a single location prior to treatment.

On November 10, 2011, Doe Run requested approval from the MoDNR to conduct a pilot test that involves pumping mine water directly into the tailings impoundment and monitoring whether this has an effect on water quality at outfall 001. This pilot test was approved by the MoDNR in December 2011. This pilot is ongoing and, as a condition of MoDNR's approval of the pilot, Doe Run will submit a summary report by August 1, 2012.

In addition to potential water quality benefits, discharge of mine water directly to the tailings impoundment provides Doe Run with greater operational control over water levels in the tailings impoundment. This is important because management includes reducing exposed beach areas by raising water surface elevations in the tailings impoundment. Transfer of mine water to the tailings impoundment allows for a consistent water source to facilitate maintenance of a desired water surface elevation.

5.6 OTHER WATER MANAGEMENT MEASURES

No other significant water management measures are planned at this time, pending the results of the pilot tests previously mentioned.

6. PLAN IMPLEMENTATION

Implementation of the Brushy Creek SWMP is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of the potential water management measures described in Section 5, focusing on cost-effectiveness and impact on water quality;
- Identification of water management measures;
- Implementation of identified actions;
- Monitoring of implemented actions (data collection and review);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Brushy Creek SWMP discussed in this section are:

- Water management measure evaluations
- Monitoring
- Recordkeeping
- Training
- Coordination/interface with other plans
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections.

6.1 WATER MANAGEMENT MEASURE EVALUATIONS

Several water management evaluations are planned to support determination of the most effective and economical way to meet future final MSOP limits at Brushy Creek, as discussed in the preceding section. These include the following:

- Completion of two pilot studies to further evaluate chemical precipitation for achieving future final MSOP limits. These tests are designed to verify the effectiveness of the technology and provide the basis for confident engineering design and cost estimation.
- Completion of the pilot test involving pumping of mine water directly into the tailings impoundment at Brushy Creek, prior to pumping it to the mine water basin. This pilot is ongoing and, as a condition of MoDNR's approval of the pilot, Doe Run will submit a summary report by August 1, 2012.

- Upon completion of the mine water treatment pilot tests currently underway, Doe Run will evaluate of the cost-effectiveness of a mine water treatment for Brushy Creek and timing for completion of treatment construction.

The schedule is presented in Section 6.7.

6.2 MONITORING

Ongoing water quality monitoring will be continued at the Brushy Creek facility to improve the understanding of the impacts of management practices on water quality, including sources and fate of metals. For the first year of this plan, the locations identified in Table 6-1 will be sampled.

Table 6-1. Surface Water Sampling Locations for the Brushy Creek Mine.

Location	Sample ID Previously Used	Rationale
Mine water basin outfall	Brushy001	Permit-required monitoring
Mine water box	MWBox	Continued monitoring of incoming mine water
Tailings Impoundment at Barge Pump	TIBargePump	Continued monitoring of water transferred to mine water basin

These samples reflect the sampling baseline that will be continued at the Brushy Creek facility during the first plan year to verify the conclusions and observations described in the plan. Samples will be collected as often as twice monthly at each of these locations for the first 6 months of the first plan year. After the first 6 months, if the distribution of the data indicates that monthly sampling is unlikely to provide a different understanding of water quality at these locations, the monitoring may cease or monitoring frequency at some or all of the locations may be reduced to monthly or quarterly. All parameters previously analyzed will continue to be analyzed and the same sample collection and analytical methods will be followed.

Future updates to this plan will describe the additional data collected and discuss how those data are used in the evaluation of management practices. In addition to the baseline monitoring described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for surface water management at the Brushy Creek facility.

6.3 RECORD-KEEPING

Best management practices are inspected at Brushy Creek every month pursuant to the SWPPP and these inspection records will be kept on site at Brushy Creek.

6.4 TRAINING

Training was identified in the Master Surface Water Management Plan and will be an important part of the plan for Brushy Creek. Initial training will be provided to personnel directly involved in the management of water at Brushy Creek including, but not necessarily limited to:

- Maintenance personnel
- Environmental technicians

Initial training will be provided within two months of plan approval. In addition to the initial training for these personnel, annual refresher training for appropriate personnel will be conducted in conjunction with SWPPP training. The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for surface water management (including the environmental need);
- Best management practices to be used throughout the facility;
- Specific water management actions being implemented or planned;
- Water management protocols and standard operating procedures, if any;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

6.5 INTERFACE WITH OTHER PLANS

As part of an overall water management and compliance program, Doe Run has developed and maintains other plans for the Brushy Creek facility that include activities closely related to this plan: the Underground Water Management Plan (UWMP, LimnoTech, January 2012) and the Stormwater Pollution Prevention Plan (SWPPP; RMC, April 2011).

6.5.1 Underground Water Management Plan

The Brushy Creek UGWMP contains an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce solids and metals loading to surface waters at the facility from underground operations. It provides a summary of mine water flow and monitoring information and a description of activities that contribute to the presence of solids and metals in mine water. The plan provides a description of current practices used to minimize solids and metals in mine water as well as an evaluation of additional practices. The plan also provides recommendations for future activities and monitoring to support the continuing evaluation of current and potential management practices and activities for minimizing the presence of solids and associated metals in mine water pumped to the surface.

Underground water management activities can have a direct impact on water quality pumped to the surface. The following coordination activities will be considered to enhance connectivity between the two planning efforts and to maximize the utility of the information generated by each plan:

- As appropriate, communication of changes in underground water management practices between underground and surface management staff and
- As appropriate, coordination of underground and above ground sampling to support the evaluation of spatial and temporal trends in water quality.

Any significant changes in mine operation or underground water management that could affect surface water management at Brushy Creek will be discussed in future versions of the Brushy Creek SWMP.

6.5.2 Stormwater Pollution Prevention Plan

The Brushy Creek Mine Stormwater Pollution Prevention Plan (SWPPP) identifies industrial activities conducted and significant materials stored at the facility. The plan contains a description of the management practices and procedures used to minimize the exposure of activities and materials to stormwater runoff. The plan also includes a description of training and inspection procedures used to track and document activities, materials, and management practices.

Any significant changes in stormwater management activities or in the Brushy Creek SWPPP that could affect surface water management at Brushy Creek may be documented and, as necessary, discussed in future versions of the Brushy Creek SWMP.

6.6 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between April 1 and May 31, 2013. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Brushy Creek facility.

6.7 IMPLEMENTATION SCHEDULE

The schedule for the first year of water management plan implementation is presented in Table 6-2. This schedule is based on the best information available as of the date of this plan. Any deviations from this schedule will be communicated in writing to the agencies with an explanation.

Table 6-2. Implementation Schedule for First Year Surface Water Management Plan Activities at Brushy Creek.

Action	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	March 2013	April 2013	May 2013
Complete water treatment pilot tests												
Training	Initial training to be provided within 2 months of plan approval											
Plan Review & Update												

Doe Run is evaluating the feasibility of possible treatment options at Brushy Creek and other facilities. Doe Run will then move to determinations of final treatment technologies and the sequence of construction for Doe Run facilities, including Brushy Creek. If this facility is the first to be constructed, shortly after evaluation of mine water treatment is complete, design will begin for this facility. Construction permit application will be submitted upon design completion. Doe Run will provide additional information regarding schedules as appropriate.

This page is blank to facilitate double sided printing.

7. REFERENCES

Barr Engineering Co. *The Doe Run Company – Casteel Mine Pilot Testing Results and Treatment System Design Basis Report*. April 2011. (Barr, 2011).

Drew, J. D., and S. Chen, 1997. *Hydrologic Extremes in Missouri: Flood and Drought*. Missouri State Water Plan Series Volume V. Missouri Department of Natural Resources, 141 pp.

Huff, F. A., and J. R. Angel, 1992. *Rainfall Frequency Atlas of the Midwest*. Illinois State Water Survey Bulletin 71, 141 pp.

LimnoTech. *Master Surface Water Management Plan*. (LimnoTech, 2011a).

LimnoTech. *Surface Water Sampling and Analysis Plan (Revision 1)*. January 6, 2011. (LimnoTech, 2011b).

LimnoTech. *Surface Water Sampling and Analysis Plan Report*. September 30, 2011. (LimnoTech, 2011c).

LimnoTech. *Underground Water Management Plan for Brushy Creek Mine*. (LimnoTech, 2012).

Resource Environmental Management Consultants, Inc. *Stormwater Pollution Prevention Plan for Brushy Creek Mine/Mill*. (RMC, 2011).

Resource Environmental Management Consultants, Inc. *Biotreatment Pilot Test Final Results Report*. (RMC, 2012).

Simon Hydro-Search. *Hydrogeologic Investigation: Brushy Creek Mine-Mill Tailings Disposal Facility*. April 9, 1992. (Simon Hydro-Search, 1992).

U.S. Geological Survey. "History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict" (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008).

USEPA, 2009. *Urban Stormwater BMP Performance Monitoring Manual*. Chapter 7, pp. 7-10 and 7-23.

This page is blank to facilitate double sided printing.

EXHIBIT Y

SURFACE WATER MANAGEMENT PLAN for the BUICK MINE/MILL

(MSOP No. MO-0002003)

Prepared for: The Doe Run Resources Corporation
d/b/a The Doe Run Company

June 29, 2012

Revised October 29, 2012

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

This page is blank to facilitate double sided printing.

1. INTRODUCTION

This document presents the Surface Water Management Plan (SWMP) for the Buick Mine/Mill, prepared on behalf of The Doe Run Resources Corporation, d/b/a The Doe Run Company ("Doe Run"). The Buick SWMP has been prepared in accordance with the Master SWMP previously prepared by LimnoTech (LimnoTech, 2011). In keeping with the Master SWMP, this plan presents an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to attain future final effluent limits for discharges to surface waters at the facility.

1.1 FACILITY DESCRIPTION

The Buick Mine/Mill is located on the boundary of Iron and Reynolds Counties, Missouri, approximately 8.5 miles south of Viburnum (Figure 1-1). A brief history of the facility is summarized in Table 1-1.

Table 1-1. History of the Buick Mine/Mill (USGS, 2008).

Year	Event
1960	Lead deposit discovered.
1966	Tailings dam constructed.
1969	Production began under a joint venture of Amax Inc. and Homestake Mining Company; the site was operated by AMAX Lead Company of Missouri under the name Missouri Lead Operating Company.
1986	Homestake Mining Company assumed ownership and suspended mine/mill/smelter operations.
1986	St. Joseph Lead Company and Homestake Lead Company combine to form The Doe Run Company, which assumes operation of Buick Mine/Mill; operations resume.

Primary surface operations at the Buick facility involve the milling of lead, zinc and copper ore from the Buick Mine and the Casteel and Viburnum 29 mines. An aerial layout map of the Buick facility is depicted in Figure 1-2 and a more detailed view of the facility around the mill is shown in Figure 1-3. These figures show several features relevant to this SWMP, including the following:

- Mine water basin – Mine water is pumped up the service shaft to the mine water tank and drains form there to the mine water basin. Water can also be pumped from the mine water basin back to the water tank and/or to the mill. The mine water basin also receives stormwater runoff from the drainage area surrounding the basin. Water collected in the mine water basin undergoes treatment via settling.

- Tailings impoundment – The tailings impoundment receives water from the mine water basin; process wastewater (tailings) from the milling of lead, copper, and zinc ore; truck wash water and stormwater runoff from the surrounding drainage area. Water collected in the impoundment undergoes treatment via settling.
- Mill – The mill is where ore milling occurs. The primary product of the milling process is ore concentrate or “con”, which is stored in the concentrate storage building (also shown on Figure 1-3) and then trucked off-site. The main by-product of the milling process is tailings, which are pumped to the tailings impoundment on site.
- Office building – The office building at Buick has offices, employee lockers and change rooms and hoist operations.
- Outfall 001 – Outfall 001 is the permitted outfall for the three-cell lagoon used to treat domestic wastewater at the Buick facility. Outfall 001 discharges to the tailings impoundment and does not discharge directly to receiving waters.
- Outfall 002 – Outfall 002 (sample ID = BuickM002) is the permitted point of for surface water discharge from the Buick facility. Mine water, tailings impoundment water, and stormwater are discharged through outfall 002 after undergoing treatment via settling and routing through the meander system and clear water basin.
- Truck washes – There are two truck washes at the Buick facility to clean vehicles leaving the facility: the ore truck wash and the concentrate (con) truck wash. The truck washes are described in greater detail in Section 2.1.6 of this plan.

1.2 PLAN OBJECTIVES

As stated in the Master SWMP, the objective of the site-specific SWMPs is to evaluate the technical feasibility, practicality, and effectiveness of procedures and methodologies for management of process wastewater, mine water, and stormwater associated with Doe Run mining and milling operations. The ultimate goal of this SWMP is to identify and employ water management strategies that lead to the discharge of effluent that meets applicable future final permit limits and conditions as specified in the Buick facility’s Missouri State Operating Permit (MSOP).

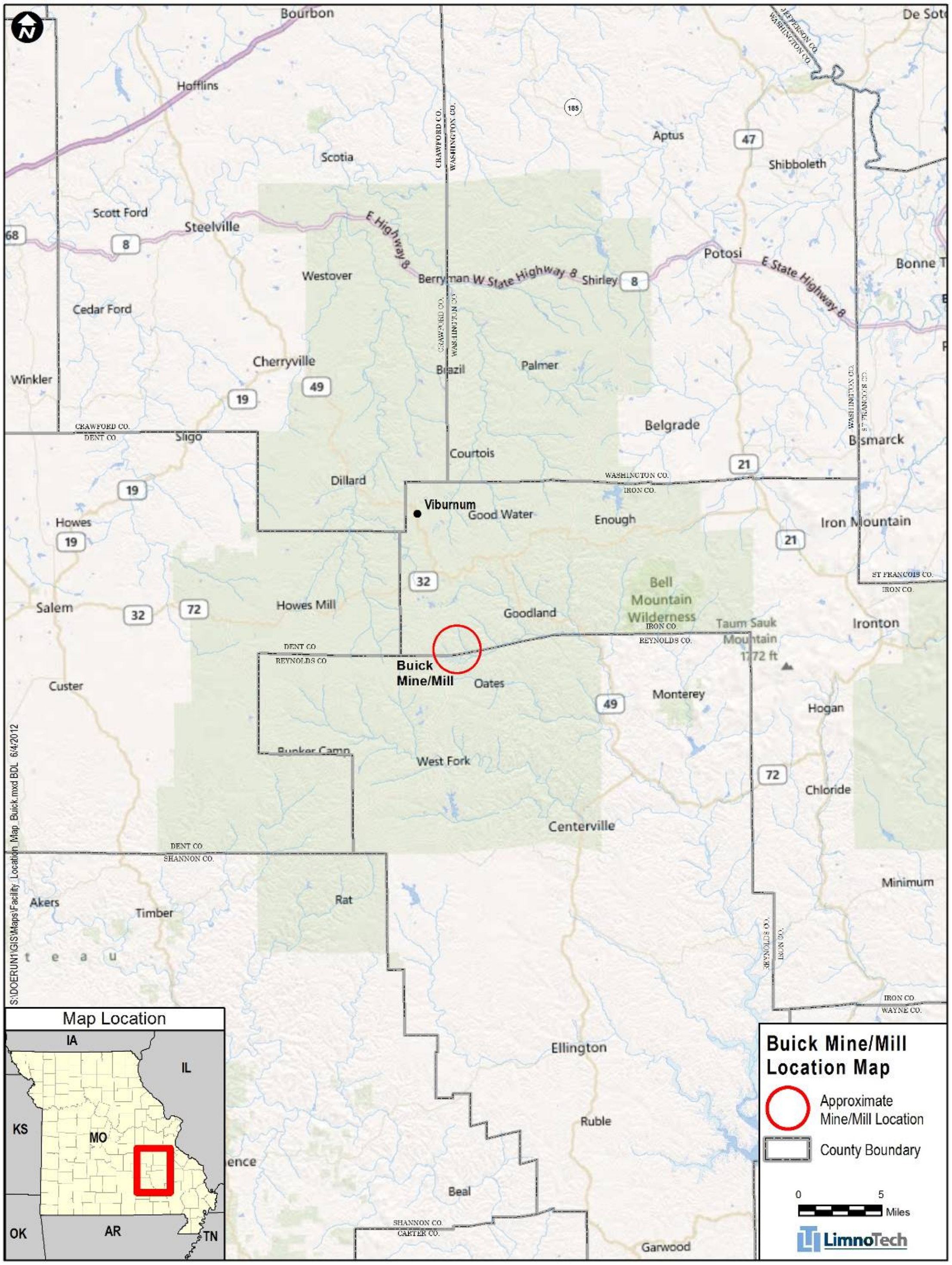


Figure 1-1. Location of the Buick Mine/Mill.

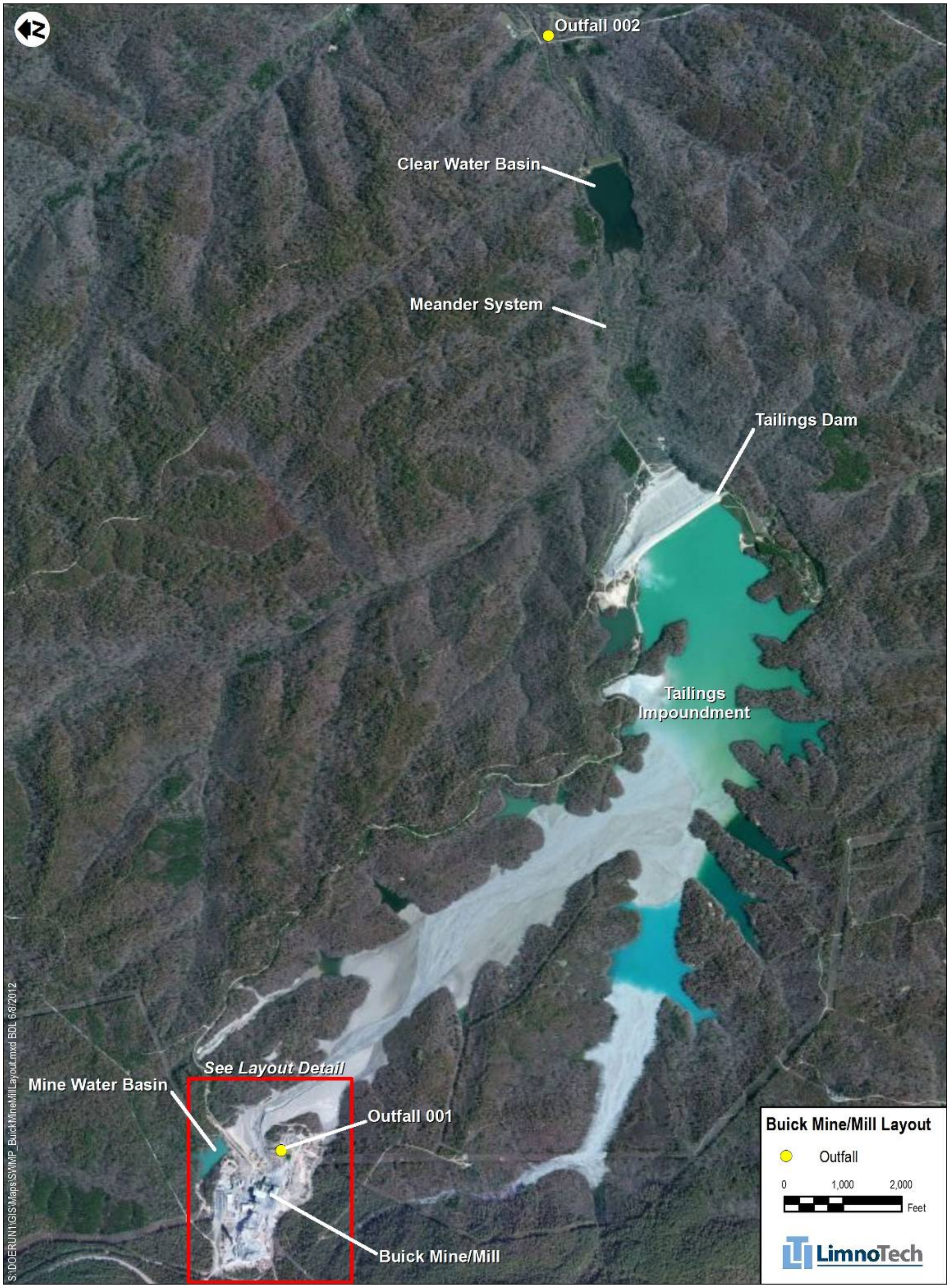


Figure 1-2. Buick Mine/Mill Layout

Figure 1-3. Buick Mine/Mill Layout Detail

1.3 SCOPE OF THE SWMP

The objective of this SWMP is to evaluate the management of water associated with Doe Run operations, specifically for the identification and implementation of actions that are expected to result in attainment of future final MSOP permit limits for the Buick Mine/Mill facility. As such, the scope includes sources, processes, flows, conditions and activities that can affect metals concentrations at permitted outfalls. It does not address other potential environmental conditions at the facility.

1.4 BUICK SURFACE WATER MANAGEMENT TEAM

Surface water management for the Buick facility will be the responsibility of the individuals named in Table 1-2. All of the individuals named are employees of The Doe Run Company.

Table 1-2. Buick Mine/Mill Surface Water Management Team.

Job Title	Name	Contact Info	Role/Responsibilities
SEMO Environmental Manager	Mark Cummings	#35 Iron County Rd. #1 Viburnum, MO 65566 573-244-8152	SEMO Environmental Management
Mill Manager	John Boyer	P.O. Box 500 Viburnum, MO 65566 573-689-4263	Oversight and management of Doe Run mill operations
Chief Engineer	Dan Buxton	P.O. Box 500 Viburnum, MO 65566 573-244-8142	Oversight of major water management measures evaluation and design
General Maintenance Manager	Gene Hites	P.O. Box 500 Viburnum, MO 65566 573-689-4151	Management of facility maintenance issues and personnel
Environmental Technician Supervisor	Amy Sanders	P.O. Box 500 Viburnum, MO 65566 573- 689-4535	Environmental data collection, management, and reporting
Buick Mill Superintendent	Brian Mangogna	P.O. Box 500 Viburnum, MO 65566 573-626-2054	Buick SWMP Primary Oversight, Implementation
Buick General Maintenance Supervisor	Bill Courtney	P.O. Box 500 Viburnum, MO 65566 573-626-2004	Buick SWMP Secondary Oversight, Implementation, and record-keeping
Buick Surface Maintenance Supervisor	Dane Cheek	P.O. Box 500 Viburnum, MO 65566 573-626-2015	Buick SWMP Secondary Oversight, Implementation

2. WATER INVENTORY

As required by the Master SWMP, the components of surface water flow at the Buick facility are discussed in detail in this section and their relative contributions to the overall water balance at the facility are presented. Each major surface water flow component is described in Section 2.1 and the overall facility surface water balance is described in Section 2.2. The water inventory for the facility is characterized with respect to outfall 002 which is the only outfall that discharges under normal operating conditions.

2.1 SURFACE WATER FLOW COMPONENTS

The major components of surface water flow for the Buick facility are:

- Outfall flows
- Mine water
- Direct precipitation
- Evaporation
- Stormwater runoff
- Truck wash water
- Infiltration

Each of these flow sources is discussed below.

2.1.1 Outfall Flows

Monthly flow measurements have been manually collected by Doe Run at outfall 002 since January 2005. Through April 2012, 96 measurements have been collected at the outfall. The median flow measurement for outfall 002 for this period was 10.5 million gallons per day (MGD). The flow data are shown in Figure 2-1.

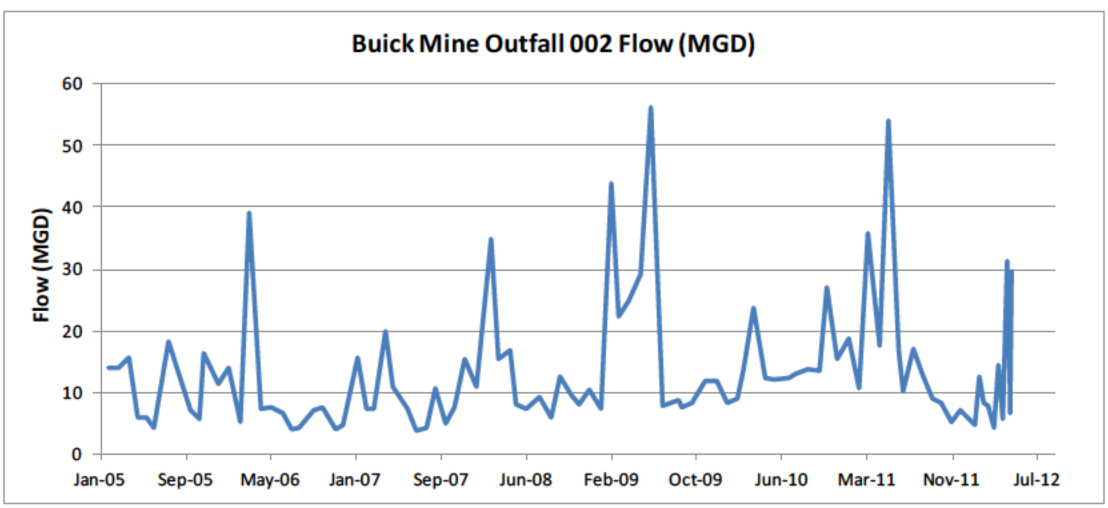


Figure 2-1. Measured Buick Outfall 002 Flows (Jan. 2005 - Apr. 2012).

The median, minimum and maximum flows for each month of the year were calculated from these data and are presented in Table 2-1.

Table 2-1. Monthly Outfall Flows (MGD) for the Buick Facility.

	Buick Outfall 002		
Month	**Median**	**Min**	**Max**
Jan	12.7	4.9	18.8
Feb	9.1	5.4	43.8
Mar	15.5	4.3	39.2
Apr	17.2	5.8	31.4
May	11	5.9	54.2
Jun	8.8	4.4	56.2
Jul	9.3	3.8	18.2
Aug	8.8	4.2	13.9
Sep	9	7.1	13.9
Oct	8.2	5.1	13.6
Nov	8.2	4.1	27.1
Dec	11.5	4.9	15.5

The median monthly flows for Buick outfall 002 are shown graphically in Figure 2-2, using the 2005 – 2012 data.

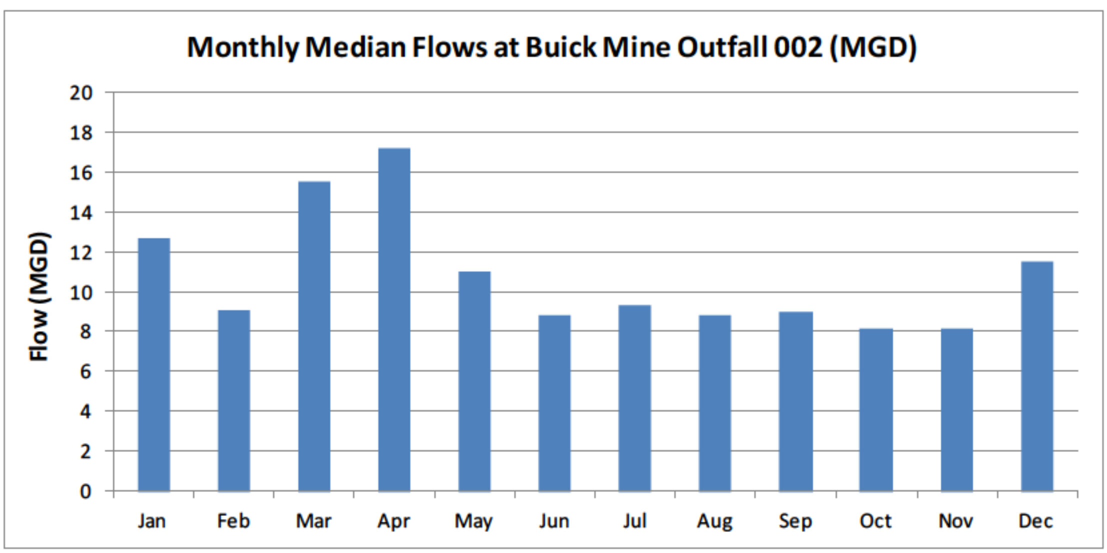


Figure 2-2. Monthly Median Flows at Buick Outfall 002 (based on monthly flow measurements collected 2005 through 2012).

Because the Buick tailings impoundment receives mine water (from the mine water basin) and direct stormwater runoff from the drainage area surrounding the impoundment, the monthly variability in flows likely has more to do with the rainfall variability than it does mine water pumping variability. In fact, Figure 2-2 clearly shows that flows are much lower at Outfall 002 from June through November, when less total rainfall occurs. Stormwater runoff is discussed in Section 2.1.5.

2.1.2 Mine Water

Mine water from the Buick Mine is pumped to the surface at the mine shaft and is routed to the mine water tank. Mine water flows from the mine water tank to the mine water basin, the mill, the crusher, and/or the truck washes. Mine water flow rates at Buick have been monitored at the surface since November 2011. A summary of the data is provided in Table 2-2.

Table 2-2. Mine Water Flowrates at Buick Mine, November 2011-June 2012.

Quantity	Value
Maximum Mine Water Pumping Capacity (current)	9,600 gpm
Average Flow Pumped to Surface (current)	2,000-4,000 gpm

The estimated mine water flows presented in Table 2-2 indicate that the average mine water flow rate at Buick is approximately 3,000 gpm (4.3 MGD).

2.1.3 Precipitation

Precipitation is important in understanding both direct volume contribution to the mine water basin and tailings impoundment, and in calculating stormwater flows. Doe Run has operated a rain gage at the Brushy Creek Mine/Mill facility since 2009, which provides useful data for evaluating storm events. However, the gage has not collected data for a long enough period to evaluate long-term trends or averages, which typically requires a relatively long period of record, usually decades. Two sources of long-term rainfall data near the Buick facility are:

- National Climatic Data Center (NCDC) Viburnum gage (#238609) – The NCDC has operated a rain gage in Viburnum since 1971.
- NCDC Salem gage (#237506) – The NCDC has operated a rain gage in Salem since 1979.

These rain gages are summarized in Table 2-3 and their locations relative to the Buick facility are shown in Figure 2-3. Based on their relatively long periods of record, either of the NCDC gages could be used to calculate long-term average values.

Table 2-3. Summary of Rain Gages Near Buick Facility.

Rain Gage	Period of Record	Data Frequency	Distance to Buick Facility (miles)

NCDC Viburnum (#238609)	1971 – 2011	15 minute	8.5
NCDC Salem (#237506)	1979 - 2011	15 minute	25.5

Inspection of the gage data from the two NCDC gages shows that each gage has had several years when data were only recorded for part of the year. In fact, only nine of the 40 years of operation for the Viburnum gage had a complete data set and only 11 out of 32 years at the Salem gage had a complete data set. Using only the complete data years, the Salem gage had a long-term average rainfall of 37.4 inches and the Viburnum gage had a long-term average rainfall of 38.7 inches. The average of these two is 38 inches.

Using the average annual rainfall value of 38 inches, the volume contribution of direct precipitation to the Buick mine water basin and tailings impoundment can be calculated, as shown in Table 2-4.

Table 2-4. Calculation of Average Annual Direct Precipitation to the Buick Mine Water Basin and Tailings Impoundment

Mine Water Basin	**Surface Area (acres)**	**Average Annual Rainfall (in)**	**Average Annual Rainfall Volume (MG)**	**Average Daily Rainfall Flow (MGD)**
Mine Water Basin	4	38	4.1	0.01
Tailings Impoundment (including Mill Reservoir)	654[1]	38	675	1.8

2.1.4 Evaporation

Both the mine water basin and the tailings impoundment have relatively large, exposed water surfaces that are subject to volume loss by evaporation. Evaporation data were obtained from the NCDC Lakeside Station, which has a period of record from 1948 to 1990. This station was located approximately 100 miles from the Buick facility. The average annual free water surface evaporation calculated from these data is about 38 inches per year, which is at the low end of the range for Missouri (Drew and Chen, 1997). This average is equal to the long-term average annual rainfall. For purposes of the overall annual water balance, this annual evaporation rate was converted to a daily “flow” as shown in Table 2-5.

[1] This includes open water areas and beach areas in the tailings impoundment.

Table 2-5. Calculation of Average Annual Evaporation from the Buick Mine Water Basin and Tailings Impoundment

Mine Water Basin	Surface Area (acres)	Average Annual Evaporation (in)	Average Annual Evaporation Volume (MG)	Average Daily Evaporation "Flow" (MGD)
Mine Water Basin	4	38	4.1	0.01
Tailings Impoundment (including Mill Reservoir)	292[2]	38	301	0.83

The estimated average annual evaporation rate (38 inches) is equal to the estimated average annual rainfall for Buick. Although these two quantities are equal, they do not occur at the same time and do not necessarily cancel each other out in the water balance, except on an annual basis.

[2] This includes only open water surface in the tailings impoundment.

Figure 2-3. Nearest Rain Gages to the Buick Facility.

2.1.5 Stormwater Runoff

Stormwater provides a source of flow to both the mine water basin and the tailings impoundment at the Buick facility. Figure 2-4 shows the drainage areas contributing stormwater flows to the mine water basin and the tailings impoundment. The Buick mine water basin and tailings impoundment have a combined drainage area of approximately 1,760 acres.

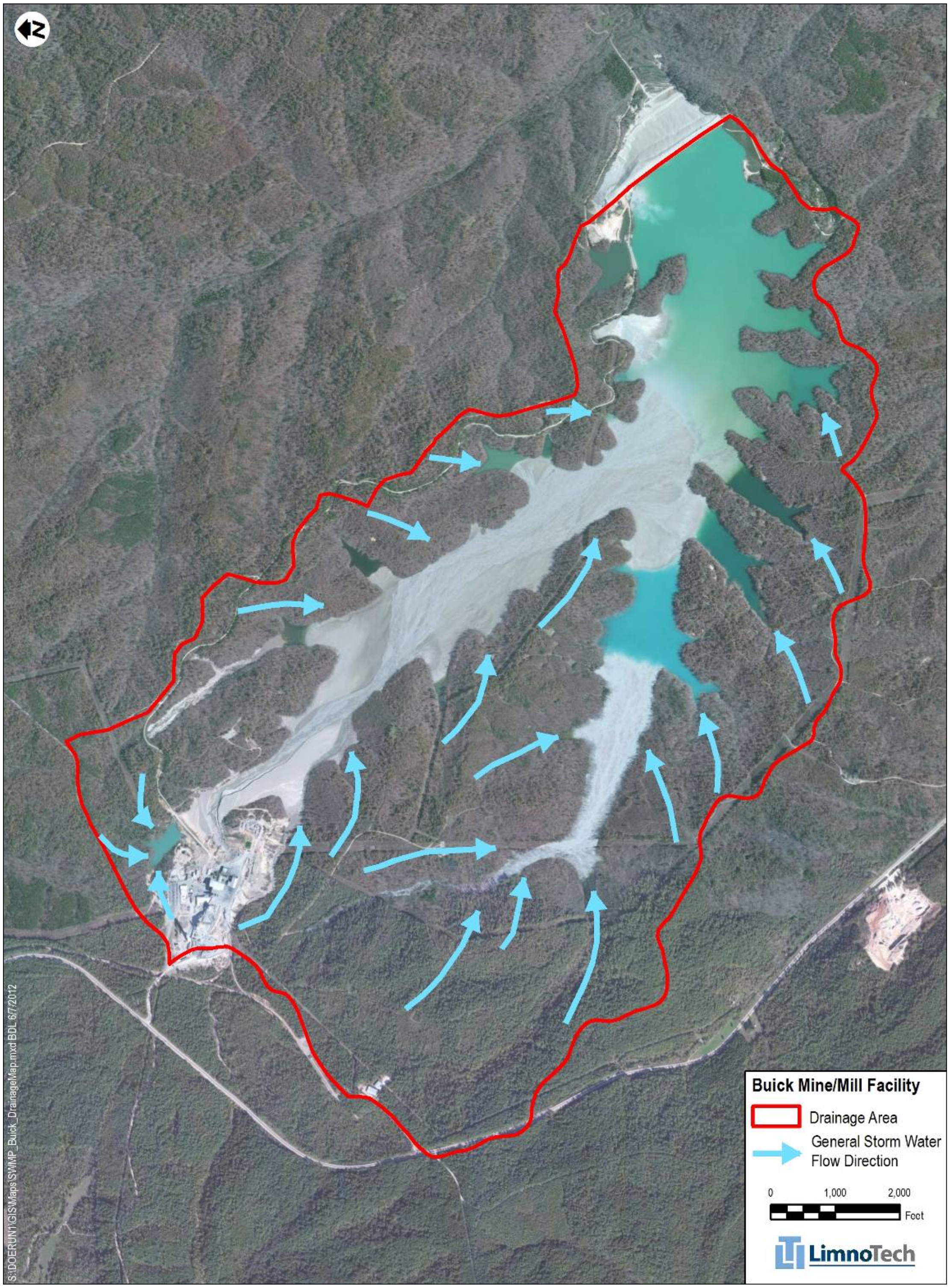


Figure 2-4. Stormwater Drainage Areas and Flow Paths at the Buick Facility

A USEPA Stormwater Management Model (SWMM) was constructed to simulate stormwater runoff to the tailings impoundment at the Buick facility from the contributing drainage area. The drainage area was delineated in ArcGIS using 10-meter elevation data. Soils, land use, and slope data were used to determine runoff characteristics using the Green and Ampt method and these data were input into SWMM. This modeling approach was previously used for the Brushy Creek Mine/Mill, where continuous flow measurements were used to adjust model parameters and verify model runoff volume predictions. Because the tailings impoundment drainage area at Buick is similar in characteristics to the Brushy Creek drainage area, the method is appropriate for use at Buick.

Rain data from the Brushy Creek rain gage for the period of April 2009 through May 2012 was used in the Buick SWMM model to simulate runoff and to calculate an average runoff/rainfall ratio, which is an estimate of the average portion of rainfall that becomes runoff to the mine water basin and the tailings impoundment. This ratio will vary with rainfall intensity but the average value is a reasonable indicator of the average runoff flow. This approach resulted in an average runoff/rainfall ratio of 0.09 for the tailings impoundment drainage area. This ratio was applied to the long-term average annual rainfall discussed in the preceding section and a long-term average annual runoff contribution to the tailings impoundment was calculated. Using this approach, the long-term average annual rainfall of 38 inches was used with the model-derived runoff/rainfall ratio and the drainage areas of the mine water basin and the tailings impoundment to calculate average annual runoff flows, as summarized in Table 2-6.

Table 2-6. Calculation of Average Annual Runoff Flows to the Buick Tailings Impoundment

Basin	Drainage Area (acres)	Average Annual Rainfall (in)	Average Annual Rainfall Volume (MG)	Runoff/ Rainfall Ratio	Average Annual Runoff Volume (MG)	Average Daily Runoff Flow (MGD)
Tailings Impoundment	1,760	38	1,816	0.09	163	0.45

The model was then run for a suite of design storms of 24-hour duration, summarized in Table 2-7, to evaluate the variability of the runoff/rainfall ratio.

Table 2-7. Characteristics of 24-hour Storm Events (Huff and Angel, 1992) and Variation of Runoff/Rainfall Ratios

Recurrence (years)	Duration (hours)	Rainfall Depth (inches)	Model-Derived Runoff/ Rainfall Ratio
1	24	2.79	0.11
2	24	3.51	0.22
5	24	4.39	0.33
10	24	5.03	0.41
25	24	5.94	0.49

These results show that the runoff/rainfall ratio will increase with storm intensity and can be many times higher than the long-term average.

2.1.6 Truck Wash Water

There are two truck washes at the Buick facility: the ore truck wash and the concentrate (con) truck wash. The operating principles and design of each truck wash are the same. Water for the truck washes is taken from the process water line that feeds the mill which, in turn, is pumped from the mine water tank. During the truck washing process at the concentrate truck wash, water is collected in floor drains inside the truck wash building and drained to a concrete settling basin beneath the truck wash. This allows solids to settle and the clarified water drains by gravity to the tailings impoundment.

In estimating truck wash usage from the ore truck wash, it was assumed that each truck is sprayed for 45 seconds at a flow of about 1,000 gpm, therefore a reasonable estimate of the truck wash water usage is 750 gallons per truck. According to personnel and records at the Buick facility, about 200 ore trucks leave the facility each day on average, for a total annual wash water volume of 37.5 million gallons, or approximately 0.1 MGD.

The con truck operates at approximately 800 gpm with an assumed 45 second wash time per truck, resulting in water usage of about 600 gallons per truck. On average, approximately 25 con trucks leave the Buick facility each day, resulting in 3.75 million gallons of wash water annually. This is equivalent to a daily flow of 0.01 MGD.

Truck wash water may provide a net increase in solids loading to the basin, which may affect metals concentrations. The impact of discharging truck wash water into the tailings impoundment at Buick is discussed in Section 3.3.3 of this plan.

2.1.7 Infiltration

Because the tailings impoundment and mine water basin were not constructed with liners, the possibility of some infiltration exists. For purposes of the overall water balance, infiltration was estimated using Darcy's law and available data. Darcy's law is:

$$Q = AK(dH/dL)$$

Where:

Q = infiltration flow (cfs)

A = surface area (ft^2)

K = hydraulic conductivity (ft/sec)

dH = vertical head difference between impoundment water surface and groundwater table (ft)

dL = horizontal distance between impoundment and downstream well where groundwater table elevation is measured (ft)

Estimates of infiltration were made separately for the tailings impoundment and the mine water basin. Each variable in the equation above was estimated using available data as described in Table 2-8 below:

Table 2-8. Parameters Used to Estimate Infiltration from Buick Tailings Impoundment

Parameter	Description	Value
Surface area	Used surface area of tailings impoundment, including open water and beach, measured from recent aerial photograph	654 acres (28,488,350 ft^2)
Hydraulic conductivity	Used estimated conductivity of tailings solids (based on grain size distribution of tailings) assumed to be covering bed of impoundment; median (D_{50}) grain size of 0.06 mm, classified as silt; horizontal hydraulic conductivity of silt ~ 10^{-4} to 10^{-6} cm/s; used median of 10^{-5} cm/s, but divided by 10 to represent lower vertical hydraulic conductivity	10^{-6} cm/sec (3.28×10^{-8} ft/sec)
Vertical head difference	Typ. water surface elevation in impoundment (1191.8 ft.) minus typ. groundwater elev. in well P3, immediately downstream of the tailings dam (1052.87 ft), based on last 2 yrs of data	139 ft
Horizontal distance	Horizontal distance between monitoring well P3 and open water in the tailings impoundment	1,000 ft

The parameter values in Table 2-8 yield an estimated potential infiltration rate from the Buick tailings impoundment of 58 gallons per minute or 0.08 MGD.

The mine water basin at Buick is located immediately upgradient of the tailings impoundment, as shown on Figures 1-2 and 1-3. Recent (March 2011) LIDAR data collected at Buick shows the water surface elevation of the mine water basin, on the date of the survey, to be 1,337 ft. above mean sea level (AMSL). This is more than 130 feet above the water level of the tailings impoundment which was approximately 1,205 ft. AMSL on the date of the LIDAR survey. This shows that the mine water basin is perched upgradient of the tailings impoundment, suggesting that any infiltration from the mine water basin will seep into the tailings and not directly affect underlying groundwater. Furthermore, any infiltration flow is much smaller than the direct flow of mine water to the tailings impoundment. Infiltration from the mine water basin is therefore not a significant component of the Buick water balance.

2.2 FACILITY WATER BALANCE

The calculations of flows to and from the Buick mine water basin and tailings impoundment, described in the preceding sections of this plan, were combined to produce an overall water balance for the mine water basin and tailings impoundment. A schematic of the water balance for the Buick mine water basin and tailings impoundment is presented in Figure 2-5.

It is important to note that mine water is the major source of flow to the mine water basin (and outfall 002) on an annual basis. The flow rates shown generally balance, accounting for some inherent uncertainty in the estimates.

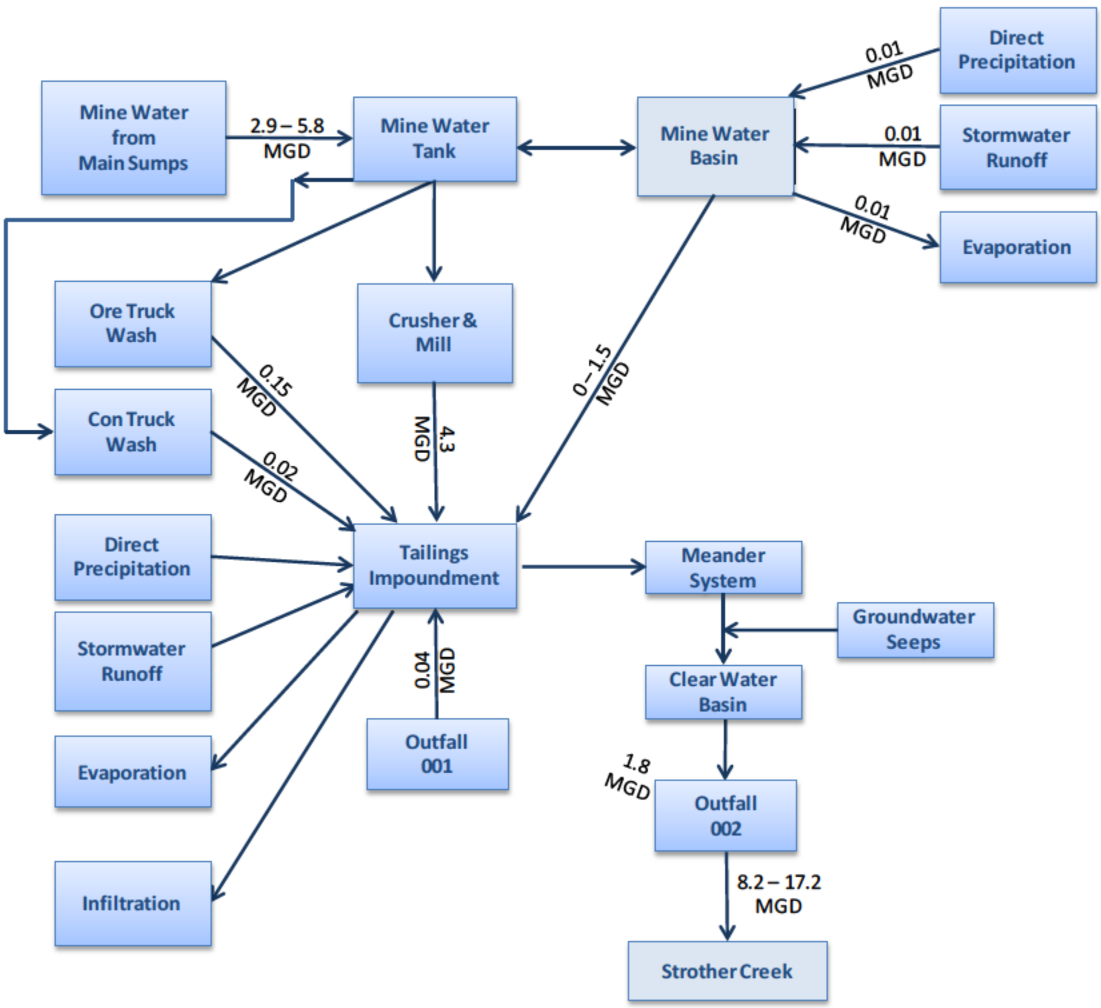


Figure 2-5. Overall Water Balance for Buick Mine Water Basin and Tailings Impoundment (Mine Water Inflows, Flows from Mine Water Basin to Tailings and Outfall Flows Shown as Ranges, Other Flows Represent Averages).

3. SOURCE IDENTIFICATION

As stated in the Master SWMP (LimnoTech, 2011a), the source identification component of the Site-Specific SWMP involves identifying and investigating the potential sources of target metals to surface water at each facility and identifying the pathways by which metals might enter surface water flows. This section of the Buick SWMP describes the following components of the source identification process at the facility:

- Surface Water Data Summary – An overview of the data used in this SWMP.
- Outfall Data Assessment – A review of outfall monitoring data to identify priorities for the Surface Water Management Plan.
- Sources of Metals Loading to Outfalls – Describes three sources of metals loading in water to outfall 002: mine water, stormwater runoff, and truck wash water.
- Source Assessment Summary – Summarizes the sources evaluated for the Buick facility and presents conclusions.

Further discussion of the fate and transport of metals from these sources is presented in Section 4 of this plan.

3.1 SURFACE WATER DATA SUMMARY

The analysis to support the Buick SWMP relies on data from three different sampling efforts, which are described in greater detail below:

- Monthly outfall sampling as required by the Buick facility's MSOP.
- Sampling conducted specifically for the SWMP in March-May 2011, as outlined in the Surface Water Sampling and Analysis Plan (LimnoTech, 2011b).
- Supplemental semi-monthly sampling conducted since September 2011 to support SWMP preparation.

Surface water samples collected at Buick are summarized in Tables 3-1 and 3-2. Station Buick002 refers to outfall 002, which is the point of compliance for surface water discharges from the Buick facility. Sampling at outfall 002 (Buick002) for total metals and total suspended solids has been conducted since January 2005. Analysis of dissolved metals began in January 2006.

Table 3-1. Surface Water Data Availability for Total Metals and Solids at Buick Facility, by Station[3]

Station ID	Date Range (Total)	Count of Samples						
		Tot-As	Tot-Cd	Tot-Cu	Tot-Ni	Tot-Pb	Tot-Zn	TSS
BU-ConTrkWshEff	2/16/11	No Data	1	1	1	1	1	1
BU-CrushWtr	2/16/11, 6/17/11	No Data	2	2	2	2	2	2
BU-CWB1BOT	4/19/11	No Data	1	1	1	1	1	1
BU-CWB1SUR	4/19/11	No Data	1	1	1	1	1	1
BU-CWEff	2/16/11, 6/14/11	No Data	2	2	2	2	2	2
Buick 002	1/26/05 - 4/27/12	56	55	136	62	136	141	121
BU-MW	2/16/11 - 4/17/12	No Data	17	17	17	17	17	17
BU-MWAbTI	2/16/11 - 4/17/12	No Data	17	17	17	17	17	17
BU-MWB1BOT	4/14/11	No Data	1	1	1	1	1	1
BU-MWB1SUR	4/14/11	No Data	1	1	1	1	1	1
BU-MWB2BOT	4/14/11	No Data	1	1	1	1	1	1
BU-MWB2SUR	4/14/11	No Data	1	1	1	1	1	1
BU-MWBEff	2/16/11, 6/17/11	No Data	2	2	2	2	2	2
BU-OreTrkWshEff	2/16/11, 6/17/11	No Data	2	2	2	2	2	2
BU-PumpBack	2/16/11, 6/14/11	No Data	2	2	2	2	2	2
BU-StrmTWCrshDis	2/16/11, 6/17/11	No Data	2	2	2	2	2	2
BU-ThickEff	2/16/11, 6/17/11	No Data	2	2	2	2	2	2
BU-TI1BOT	4/19/11	No Data	1	1	1	1	1	1
BU-TI1SUR	4/19/11	No Data	1	1	1	1	1	1
BU-TI2BOT	4/19/11	No Data	1	1	1	1	1	1
BU-TI2SUR	4/19/11	No Data	1	1	1	1	1	1
BU-TI3BOT	4/19/11	No Data	1	1	1	1	1	1
BU-TI3SUR	4/19/11	No Data	1	1	1	1	1	1
BU-TI4BOT	4/19/11	No Data	1	1	1	1	1	1
BU-TI4SUR	4/19/11	No Data	1	1	1	1	1	1
BU-TIDecant	2/16/11 - 4/17/12	No Data	17	17	17	17	17	17
BU-TIDis	2/16/11, 6/14/11	No Data	2	2	2	2	2	2
BU-TISeep	2/16/11, 6/14/11	No Data	2	2	2	2	2	2
BU-TrkWStrmWEffBU	2/16/11, 6/17/11	No Data	2	2	2	2	2	2

[3] On-site sample locations only; receiving water sample locations are not listed.

Table 3-2. Surface Water Data Availability for Dissolved Metals at Buick Facility, by Station.

Station ID	Date Range (Dissolved)	Count of Samples					
		Dis-As	Dis_Cd	Dis-Cu	Dis-Ni	Dis-Pb	Dis-Zn
BU-ConTrkWshEff	2/16/11	No Data	1	1	1	1	1
BU-CrushWtr	2/16/11, 6/17/11	No Data	2	2	2	2	2
BU-CWB1BOT	4/19/11	No Data	1	1	1	1	1
BU-CWB1SUR	4/19/11	No Data	1	1	1	1	1
BU-CWEff	2/16/11, 6/14/11	No Data	2	2	2	2	2
Buick 002	1/26/05 - 4/27/12	32	23	89	38	89	89
BU-MW	2/16/11 - 4/17/12	No Data	17	17	17	17	17
BU-MWAbTI	2/16/11 - 4/17/12	No Data	17	17	11	17	17
BU-MWB1BOT	4/14/11	No Data	1	1	1	1	1
BU-MWB1SUR	4/14/11	No Data	1	1	1	1	1
BU-MWB2BOT	4/14/11	No Data	1	1	1	1	1
BU-MWB2SUR	4/14/11	No Data	1	1	1	1	1
BU-MWBEff	2/16/11, 6/17/11	No Data	2	2	2	2	2
BU-OreTrkWshEff	2/16/11, 6/17/11	No Data	2	2	2	2	2
BU-PumpBack	2/16/11, 6/14/11	No Data	2	2	2	2	2
BU-StrmTWCrshDis	2/16/11, 6/17/11	No Data	2	2	2	2	2
BU-ThickEff	2/16/11, 6/17/11	No Data	2	2	2	2	2
BU-TI1BOT	4/19/11	No Data	1	1	1	1	1
BU-TI1SUR	4/19/11	No Data	1	1	1	1	1
BU-TI2BOT	4/19/11	No Data	1	1	1	1	1
BU-TI2SUR	4/19/11	No Data	1	1	1	1	1
BU-TI3BOT	4/19/11	No Data	1	1	1	1	1
BU-TI3SUR	4/19/11	No Data	1	1	1	1	1
BU-TI4BOT	4/19/11	No Data	1	1	1	1	1
BU-TI4SUR	4/19/11	No Data	1	1	1	1	1
BU-TIDecant	2/16/11 - 4/17/12	No Data	17	17	17	17	17
BU-TIDis	2/16/11, 6/14/11	No Data	2	2	2	2	2
BU-TISeep	2/16/11, 6/14/11	No Data	2	2	2	2	2
BU-TrkWStrmWEffBU	2/16/11, 6/17/11	No Data	2	2	2	2	2

Sampling procedures and analytical methods were documented in a surface water sampling and analysis plan (SWSAP) report in 2011 (LimnoTech, 2011c). Three discrete sampling events were conducted at Buick in February 2011, April 2011, and June 2011. Not every location was sampled during every event, but every location in Tables 3-1 and 3-2 was sampled during at least one event. Beginning in September 2011, stations Buick002, MW, AbTI, and TIDecant were sampled twice/month to provide additional data in support of the Buick SWMP. At the time of this report, semi-monthly data have been received and validated through April 2012. These sample locations are shown in Figure 3-1.

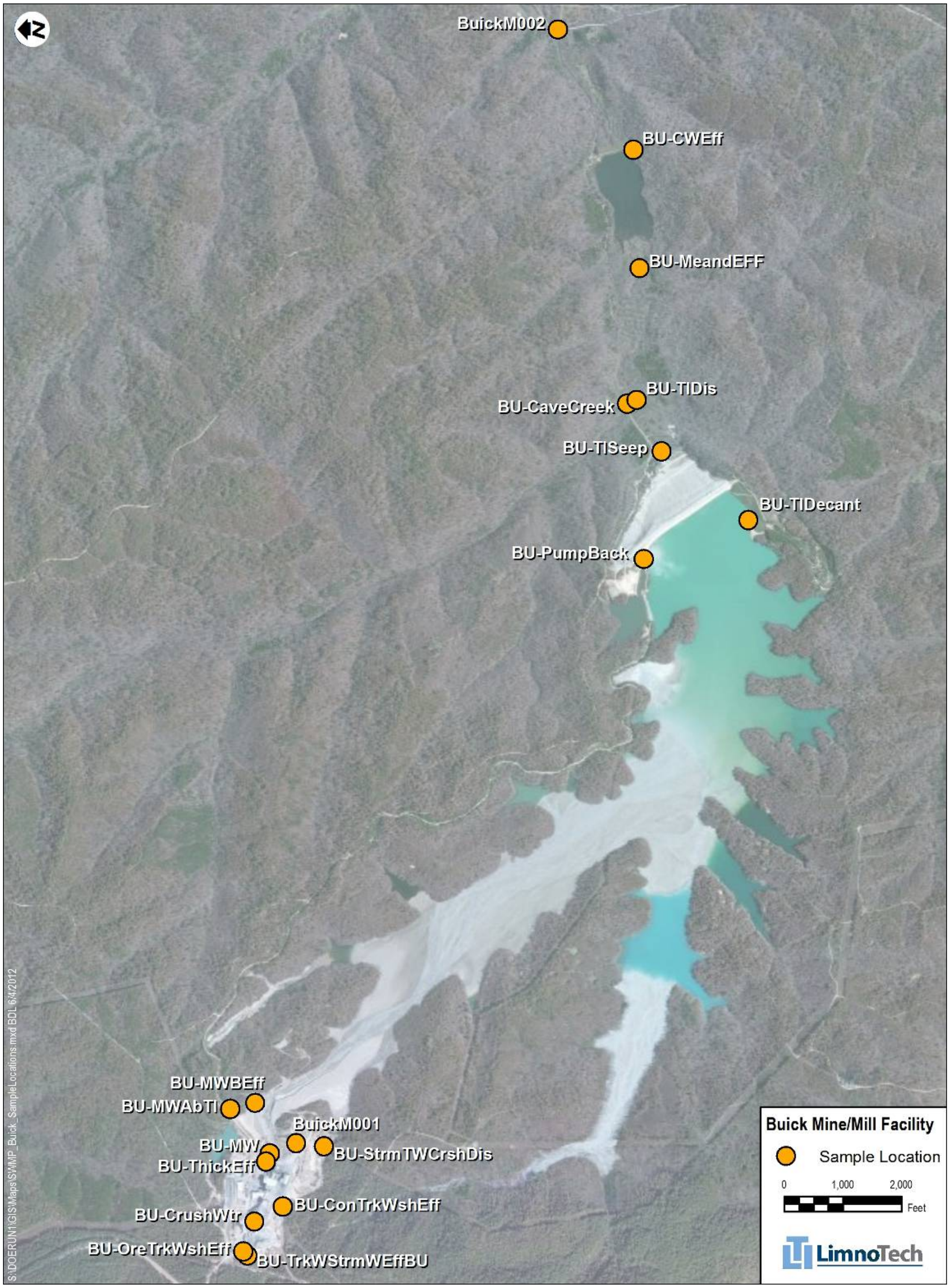


Figure 3-1. Buick Surface Water Sample Locations

3.2 OUTFALL DATA ASSESSMENT

The primary objective of this SWMP is to evaluate procedures and methodologies for management of water with the ultimate goal of discharging effluent that meets applicable future final MSOP limits, therefore the Buick outfall data were analyzed to identify priorities for water management. The following sections present the following evaluations:

- Comparisons of outfall data to future final MSOP limits
- Comparison of total and dissolved metals in effluent at the outfalls
- Evaluation of seasonal variability of the outfall data.

3.2.1 Comparison of Outfall Data to Future Final MSOP Limits

Effluent monitoring data from Buick outfall 002 were evaluated in reference to the future final discharge limits in the MSOP for the Buick Mine/Mill which become effective in September 2012. The limits for the primary constituents of interest for outfall 002 are summarized in Tables 3-3.

Table 3-3. Future Final MSOP Limits for the Buick Mine/Mill (Outfall 002).

Parameter	Future Final Effluent Limits	
	Daily Maximum (μg/L)	Monthly Average (μg/L)
Arsenic, total recoverable	32.7	16.3
Cadmium, total recoverable	1.2	0.6
Copper, total recoverable	85.8	42.8
Lead, total recoverable	56.6	28.2
Nickel, total recoverable	292	145.5
Zinc, total recoverable	434.5	216.5

Effluent limits for outfall 001 (domestic wastewater) are also specified in the Buick MSOP, but are not presented here because this discharge is from the three cell wastewater treatment lagoon.

3.2.1.a Time Series Plots for Buick Outfall Data

Time-series plots of total metals concentrations at outfall 002 for arsenic, cadmium, copper, lead, nickel, zinc, and TSS are presented on the following pages. Future final MSOP effluent limits are shown on the plots to facilitate comparison of data with those limits.

Total arsenic effluent data are shown in Figure 3-2 for outfall 002. Monitoring for arsenic was initiated in October 2009. Between October 2009 and April 2012, 100%

of all effluent samples were below both the future final daily maximum and future final monthly average MSOP limits for total arsenic.

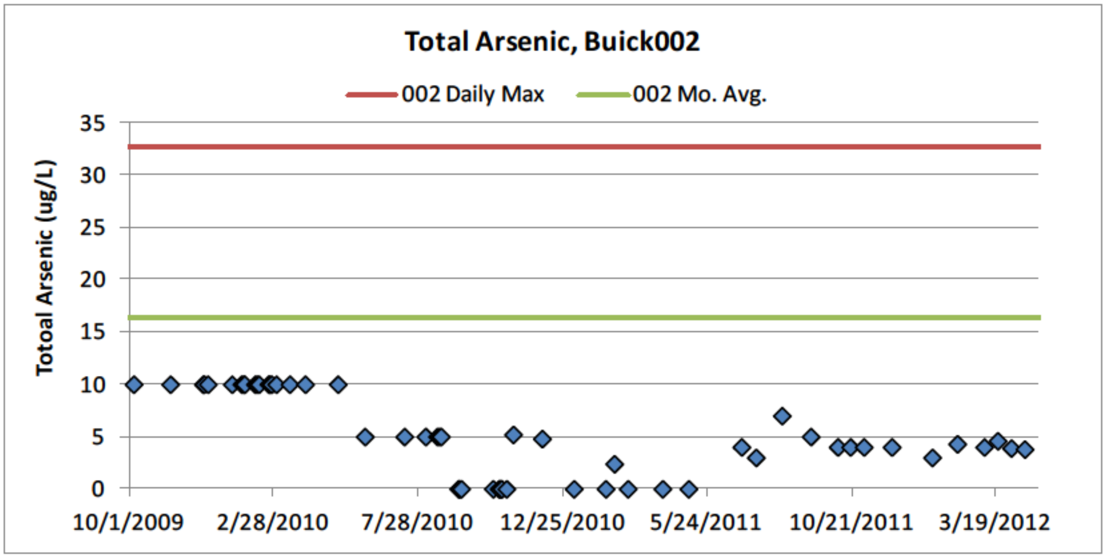


Figure 3-2. Time Series Plot for Total Arsenic at Buick002, October 2009-April 2012.

Total cadmium data are shown in Figure 3-3 for outfall 002 for the time period of June 2010 through April 2012[4]. During this period, four samples at outfall 002 (7%) were higher than the future final daily maximum limit, and six (11%) samples were higher than the future final monthly average limit for cadmium at 002. However all data since March 2011 have been below both limits.

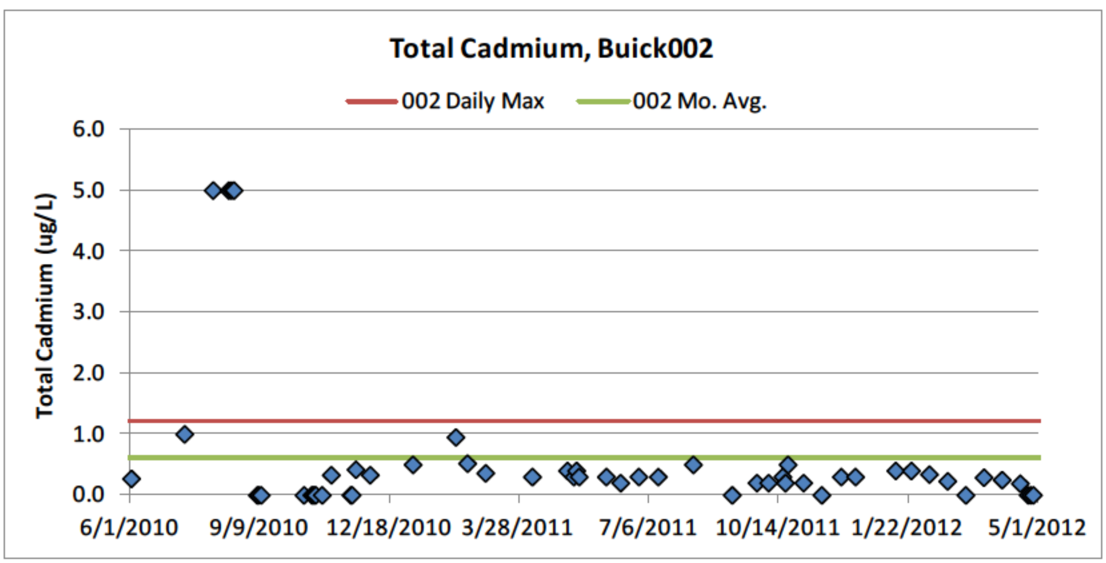


Figure 3-3. Time Series Plot for Total Cadmium at Buick002, June 2010-April 2012.

[4] These dates were selected because prior to June 2010, a detection limit of 5-10 µg/L was used for cadmium, which exceeds all MSOP limits for total cadmium.

Total copper effluent data are shown in Figure 3-4 for outfall 002. Between January 2005 and April 2012, 100% of all effluent samples were below both the future final daily maximum and future final monthly average MSOP limits for total copper.

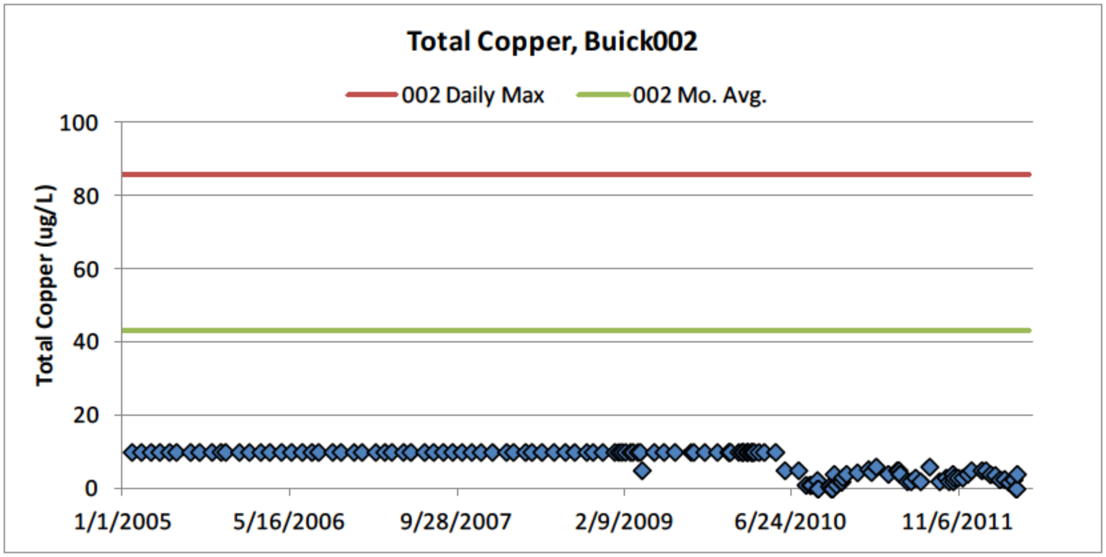


Figure 3-4. Time Series Plot for Total Copper at Buick002, January 2005-April 2012.

Total lead effluent data are shown in Figure 3-5 for outfall 002, between January 2005 and April 2012. At outfall 002, 65 samples (48%) were higher than the future final monthly average limit and 7 samples (5%) were higher than both the future final daily maximum and future final monthly average limits.

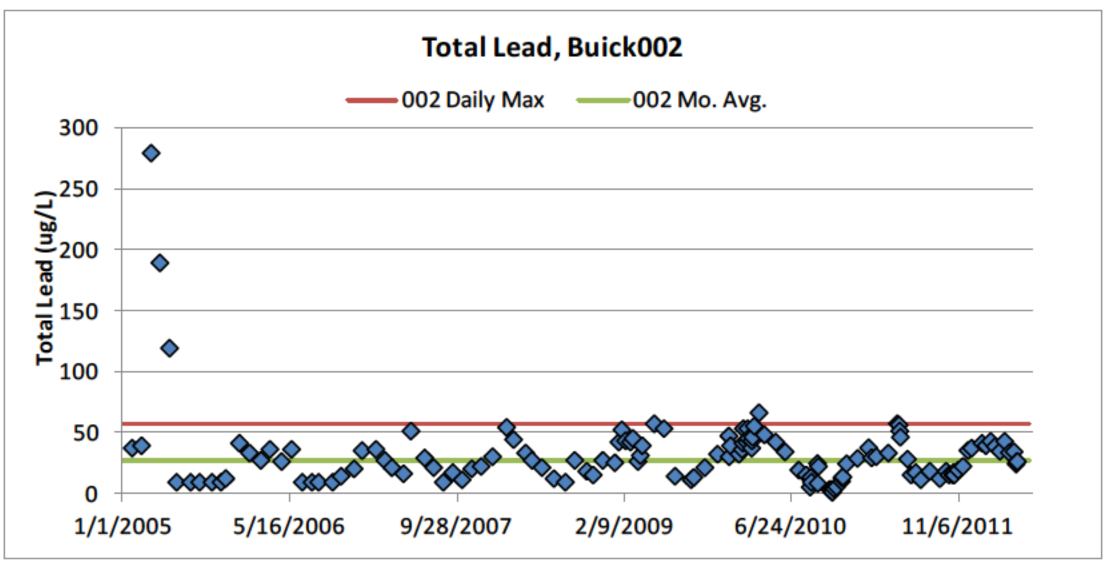


Figure 3-5. Time Series Plot for Total Lead at Buick002, January 2005-April 2012.

Total nickel effluent data are shown in Figure 3-6 for outfall 002. Monitoring for arsenic was initiated in October 2009. Between October 2009 and April 2012, nine (15%) samples were higher than the future final monthly average limit for nickel at 002. All samples at outfall 002 were below the future final daily maximum limit.

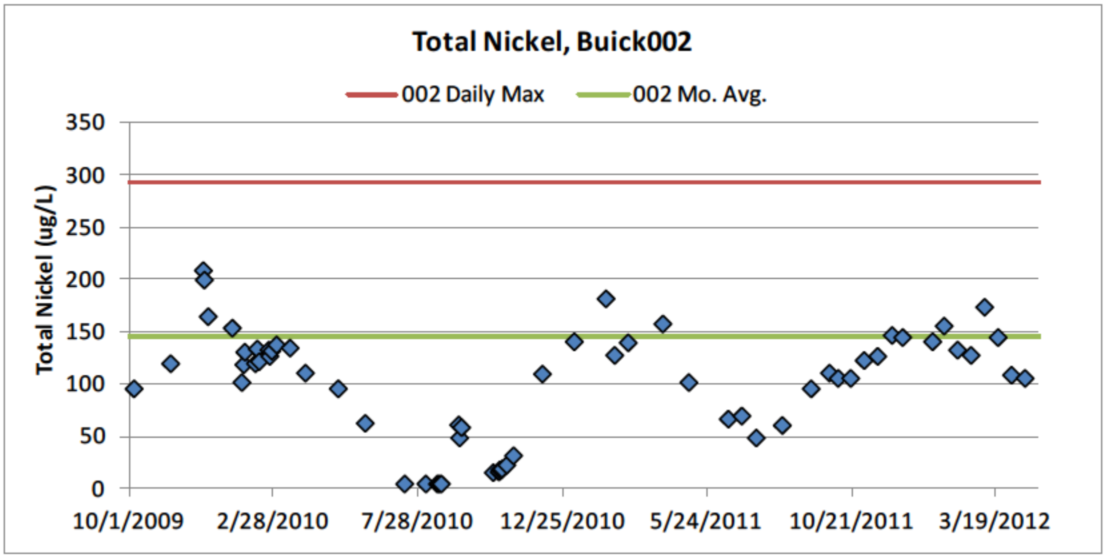


Figure 3-6. Time Series Plot for Total Nickel at Buick002, October 2009-April 2012.

Figure 3-7 shows total zinc concentrations at outfall 002 between January 2005 and April 2012. 80 samples (57%) were higher than the future final monthly average limit and 34 samples (24%) were higher than both the future final daily maximum and future final monthly average limits.

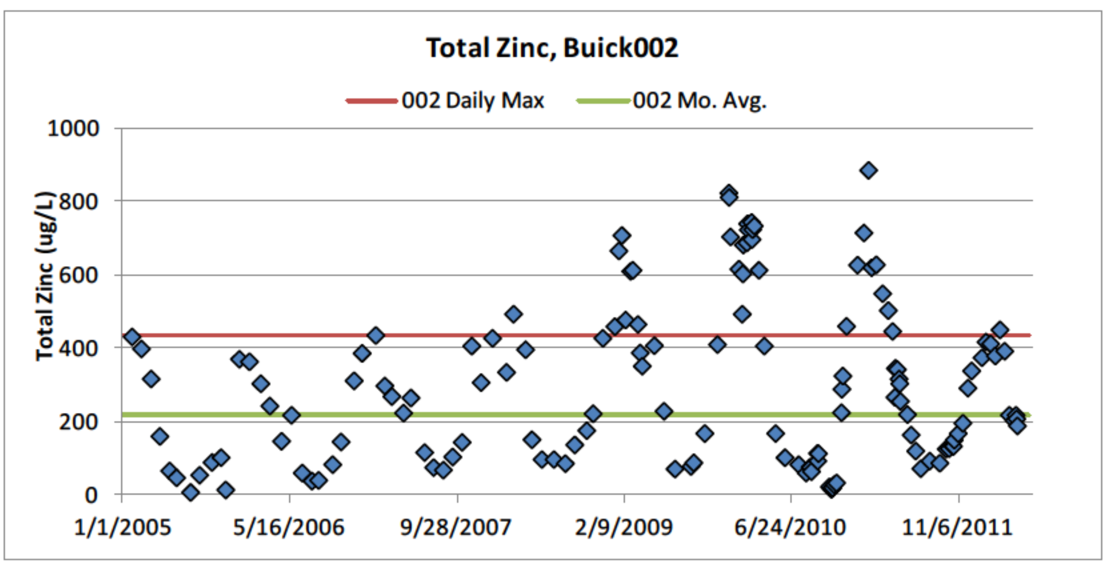


Figure 3-7. Time Series Plot for Total Zinc at Buick002, January 2005-April 2012.

TSS concentrations measured at outfall 002 between January 2005 and April 2012 are shown in Figure 3-8. During this monitoring period, all of sampling results were below the future final daily maximum and future final monthly average limits for TSS.

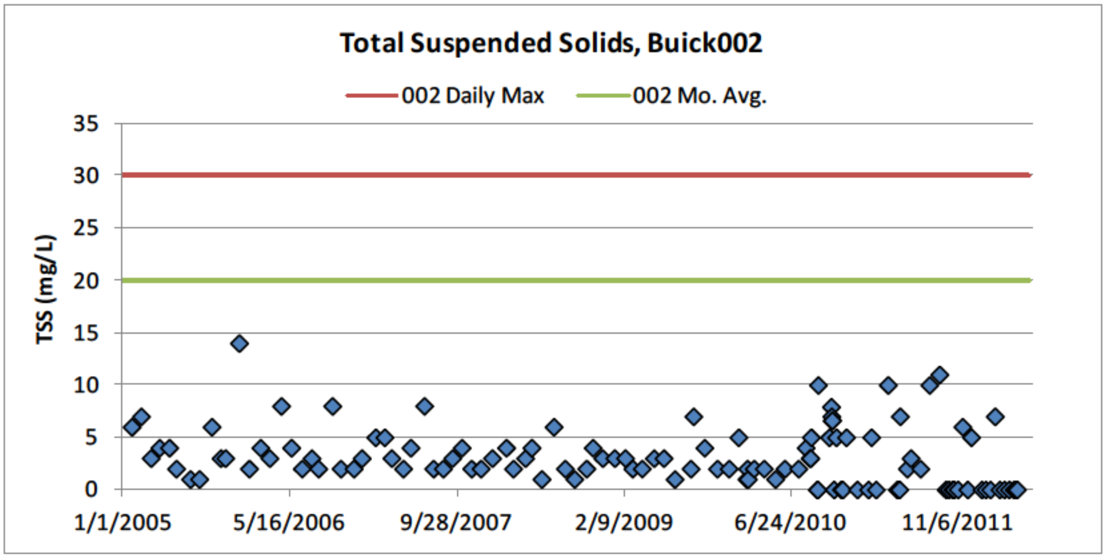


Figure 3-8. Time Series Plot for TSS at Buick002, January 2005-April 2012.

Table 3-4 summarizes the data presented in the preceding section, in terms of the number of samples and percent of samples exceeding future final MSOP limits for outfall 002.

Table 3-4. Summary of Samples Higher Than Future Final MSOP Limit for Buick Outfall 002.

Parameter	Total Samples	Monthly Avg Limit		Daily Max Limit	
		# Samples	% of Samples	# Samples	% of Samples
Tot-As	56	0	0%	0	0%
Tot-Cd*	55	6	11%	4	7%
Tot-Cu	136	0	0%	0	0%
Tot-Pb	136	65	48%	7	5%
Tot-Ni	62	9	15%	0	0%
Tot-Zn	141	80	57%	34	24%
TSS	121	0	0%	0	0%

*Only includes samples in June 2010 and later

3.2.1.b Probability Plots for Buick Outfall 002 Data

Probability plots were developed for the Buick outfall 002 data to provide an alternate tool for evaluation of future final effluent limits attainment, using the effluent probability method (USEPA, 2009). These plots present rank-based cumulative probabilities of the outfall data with future final MSOP effluent limits included as vertical lines to facilitate comparison of data to the limits. The probability plots presented here reflect existing conditions and represent a possible indication of future conditions, if no action is taken to reduce metals loading to the outfall.

Figure 3-9 presents the probability plot for total arsenic for outfall 002. The probability plot for total arsenic demonstrates that 100% of samples at outfall 002 were in compliance with the MSOP future final effluent limits for total arsenic.

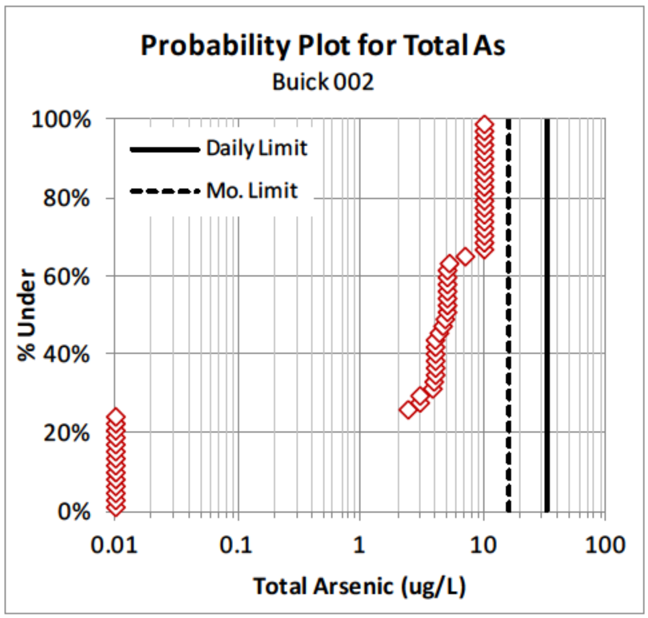


Figure 3-9. Probability Plot for Total Arsenic, Buick002.

The probability plot for total cadmium for outfall 002 is presented in Figure 3-10. As previously described, only data for the period of June 2010 to April 2012 were plotted for total cadmium because prior to June 2010, a detection limit of 5-10 µg/L was used for cadmium, resulting in numerous non-detect samples. Based on these historical data, the probability of meeting the future final monthly average limit for total cadmium is about 88% at the outfall if nothing further is done to reduce metals in the discharge.

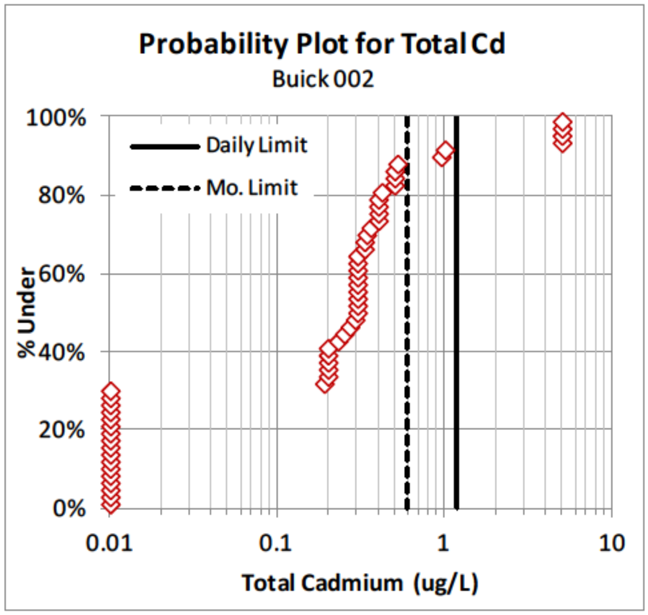


Figure 3-10. Probability Plot for Total Cadmium, Buick002.

Figure 3-11 presents the probability plot for total copper for outfall 002. The probability plot for total copper demonstrates that 100% of samples at outfall 002 were in compliance with the MSOP future final effluent limits for total copper.

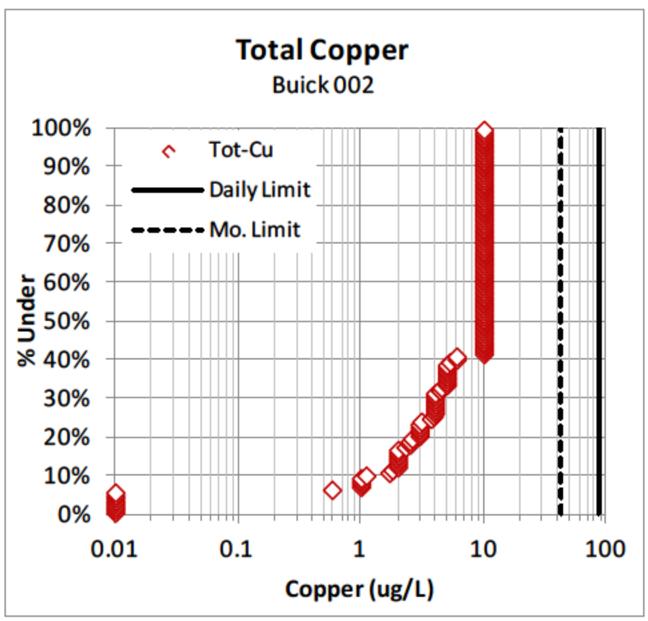


Figure 3-11. Probability Plot for Total Copper, Buick002.

Figure 3-12 presents the probability plot for total lead for outfall 002. This plot shows that the probability of total lead in the effluent meeting future final MSOP limits is approximately 47% at outfall 002 if nothing further is done to reduce metals in the discharge.

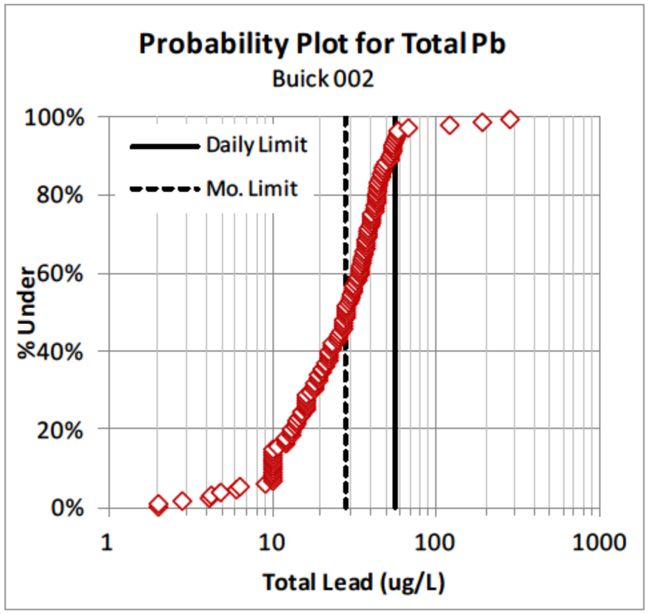


Figure 3-12. Probability Plot for Total Lead, Buick002.

Figure 3-13 presents the probability plot for total nickel for outfall 002. This plot shows that the probability of total nickel in the effluent meeting future final MSOP limits is approximately 80% at outfall 002 if nothing further is done to reduce metals in the discharge.

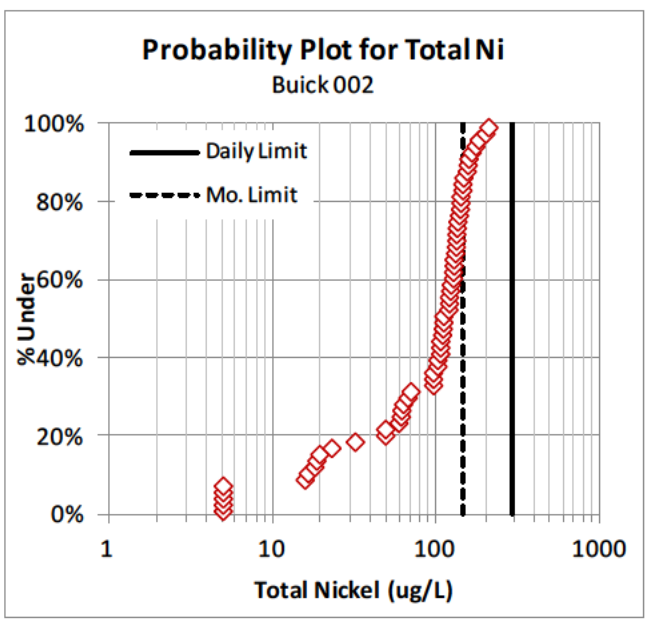


Figure 3-13. Probability Plot for Total Nickel, Buick002.

The probability plot for total zinc at outfall 002 is presented in Figure 3-14. This plot indicates that the probability of effluent attaining the future final MSOP limits for total zinc at outfall 002, based on these historical data, is about 42% if nothing further is done to reduce metals in the discharge.

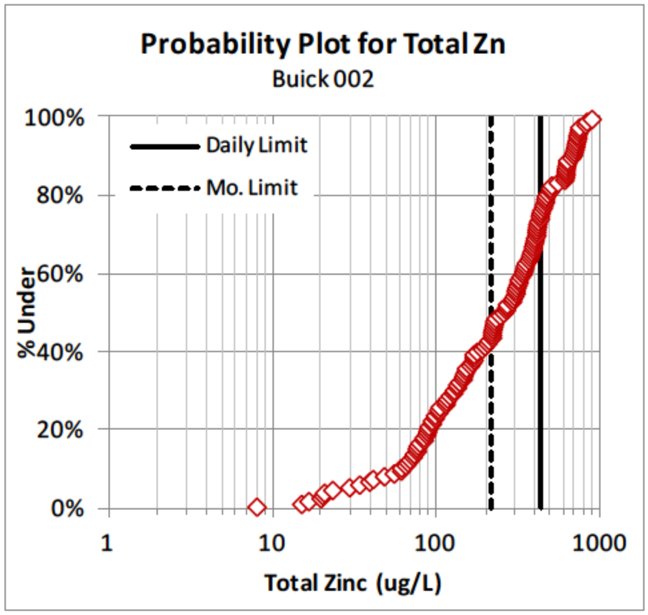


Figure 3-14. Probability Plot for Total Zinc, Buick002.

These analyses suggest that lead, nickel and zinc are less likely than arsenic, cadmium and copper to attain their respective future final MSOP limits, assuming no additional treatment, and are therefore a higher control priority at Buick.

In addition to concentrations of metals at the Buick outfall that are higher than the future final MSOP limits, effluent from the Buick outfall 002 has historically failed to pass chronic whole effluent toxicity (WET) tests. Given the elevated concentrations of lead, nickel and zinc in the effluent, it is hypothesized that measures which result in reduced metals concentrations positively impact the results of the chronic WET tests.

3.2.2 Seasonal Variability of Metals at Outfall

The Buick outfall 002 data were grouped by month for each metal to provide a graphical way to observe seasonal variations in the data. Box-and-whisker plots ("box plots") were prepared to show variation from month to month[5]. The future final MSOP limits are provided for comparison with the data.

[5] Box plots depict the median effluent concentrations, along with the upper and lower quartiles (top and bottom of box, respectively) and the minimum and maximum recorded values (upper and lower ends of whiskers).

Figure 3-15 shows a monthly box plot for measured total arsenic concentrations at outfall 002. There appears to be little monthly variation in total arsenic at outfall 002.

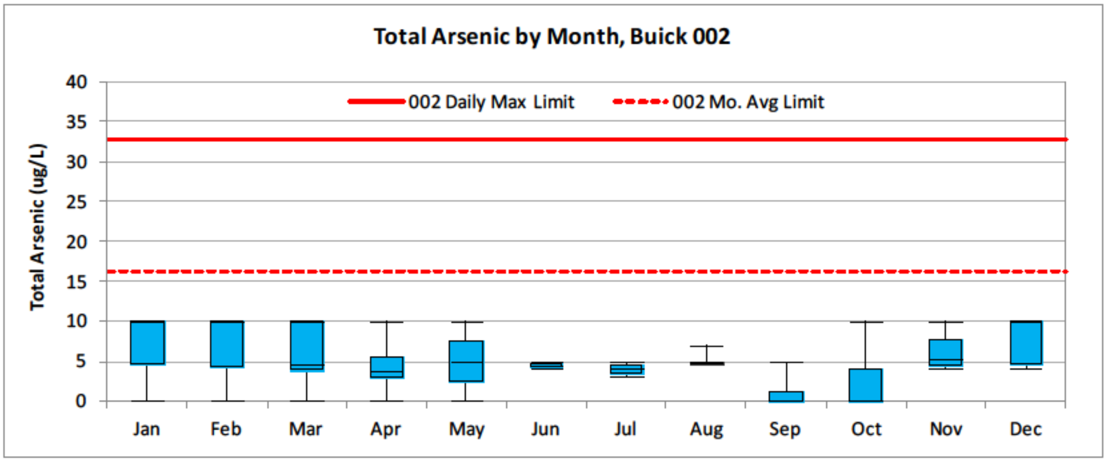


Figure 3-15. Monthly Box Plot for Total Arsenic at Buick002.

Figure 3-16 shows a monthly box plot for measured total cadmium concentrations at outfall 002.[6] There appears to be little monthly variation in total cadmium at outfall 002.

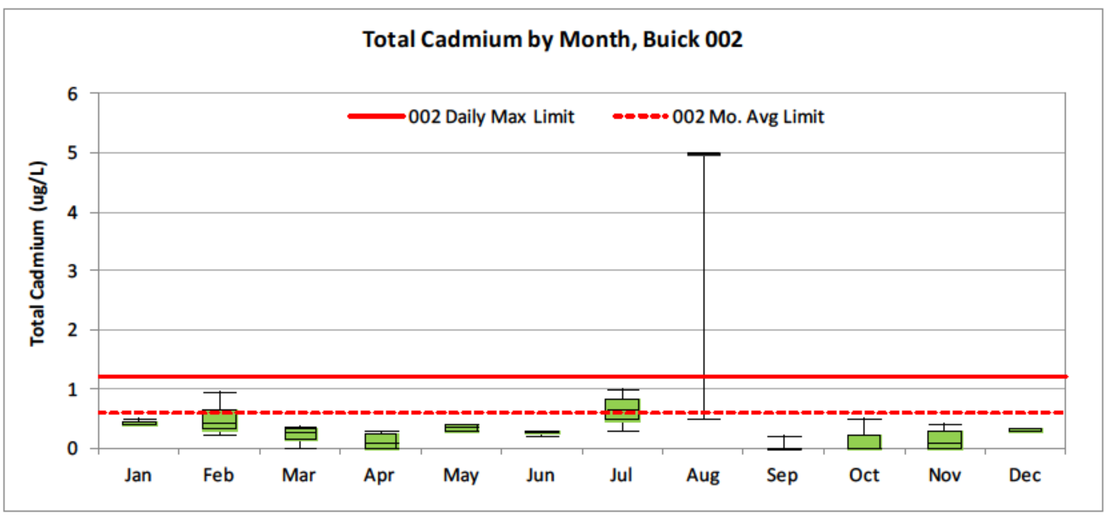


Figure 3-16. Monthly Box Plot for Total Cadmium at Buick002.

The monthly box plot for total copper at outfall 002 is presented in Figure 3-17. There appears to be little monthly variation in total copper at outfall 002.

[6] As described previously, the total cadmium plots use data collected after June 2010. This time period was selected because prior to June 2010, detection limits of both 5 µg/L and 10 µg/L were used for cadmium. Consequently, most samples were non-detect and would not add value in comparing the data to MSOP effluent limits (all effluent limits are below 5 µg/L).

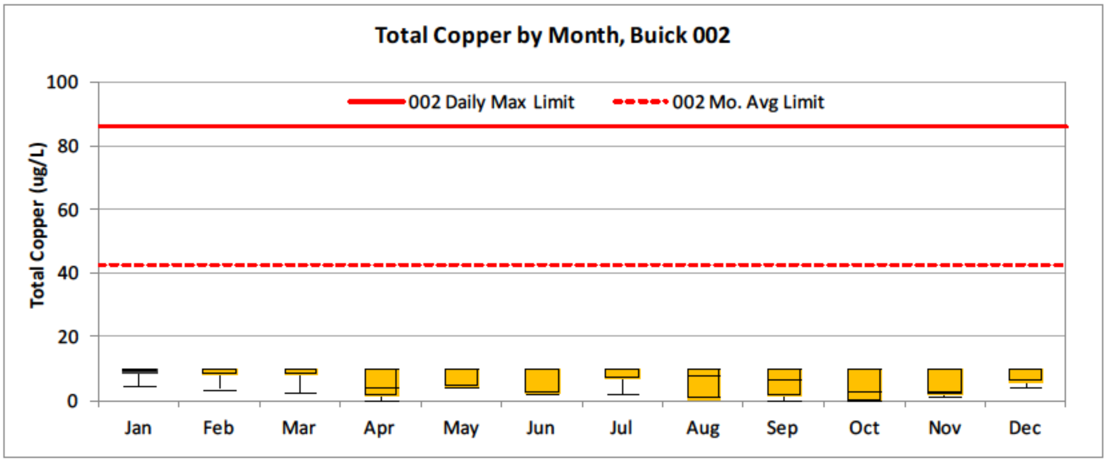


Figure 3-17. Monthly Box Plot for Total Copper at Buick002.

The monthly box plot for total lead at outfall 002 is presented in Figure 3-18. The data appear to be somewhat lower during the summer and fall months.

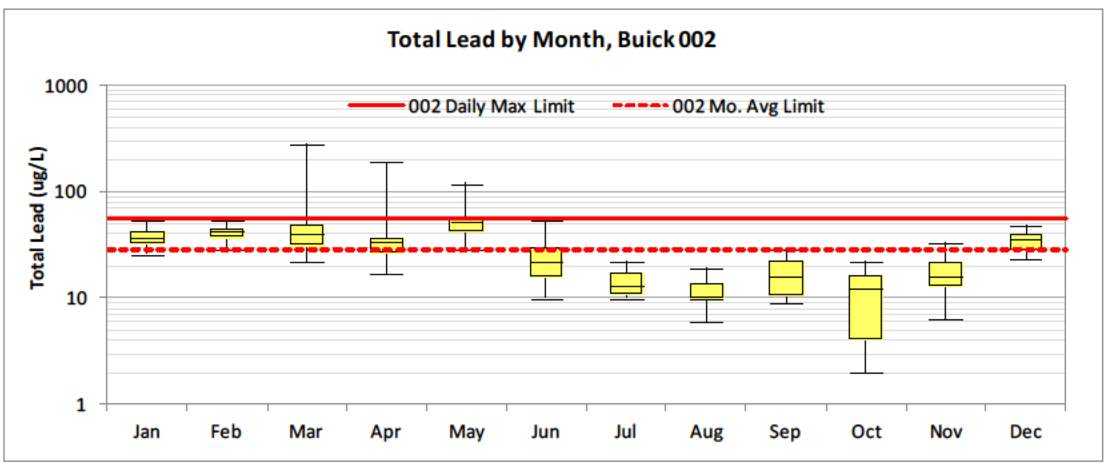


Figure 3-18. Monthly Box Plot for Total Lead at Buick002.

Figure 3-19 presents the monthly box plot for total nickel at outfall 002. Like the lead data, these data suggest a pattern of lower concentrations during summer months. This pattern will be discussed further in Section 4 of this plan.

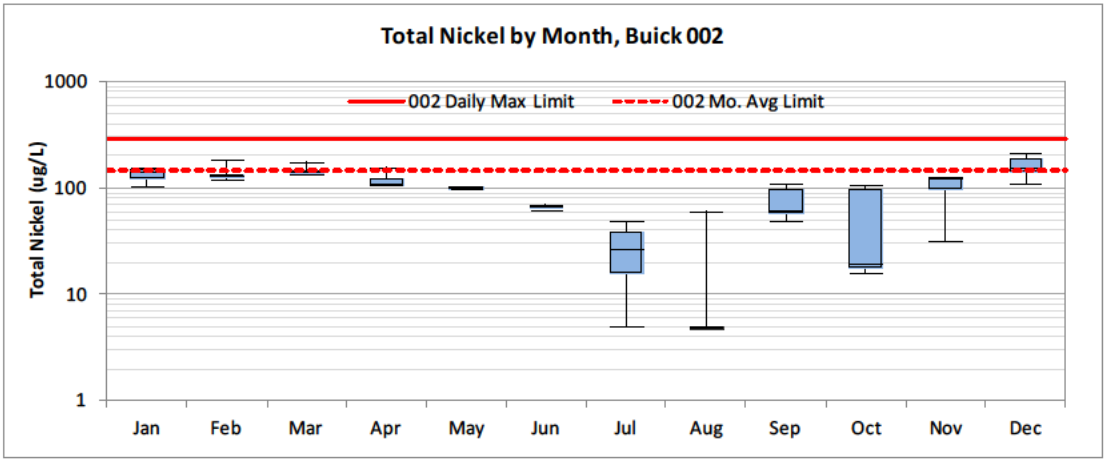


Figure 3-19. Monthly Box Plots for Total Nickel at Buick002.

Figure 3-20 presents the monthly box plot for total zinc at outfall 002. As with lead and nickel, these data suggest a pattern of seasonal variation, with lower concentrations occurring during summer and into the fall months. The seasonal pattern is much more pronounced for zinc than for other metals.

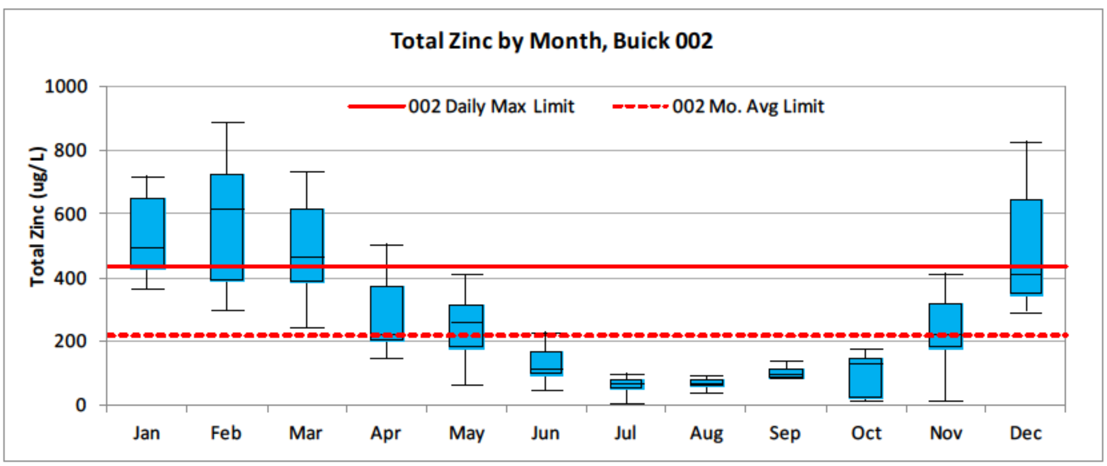


Figure 3-20. Monthly Box Plots for Total Zinc at Buick002.

3.2.3 Comparison of Dissolved Metals to Total Metals

In evaluating the potential for attainment of future final MSOP limits and potential measures to control metals in effluent, it is important to understand the relationship between dissolved and total metals. For purposes of this SWMP, this was accomplished by adding dissolved metals results to the probability plots presented in Section 3.2.1.b. This approach allows a visual qualitative determination of whether attainment is significantly influenced by metals in the dissolved phase, as opposed to metals associated with suspended solids.

Figure 3-21 shows the probability plot for total and dissolved arsenic for outfall 002. The distributions for dissolved and total cadmium are generally similar and there does not appear to be a significant difference between them with respect to the probability of meeting both future final daily and future final monthly limits. It does not appear that control of either total or dissolved arsenic at Buick is a significant issue.

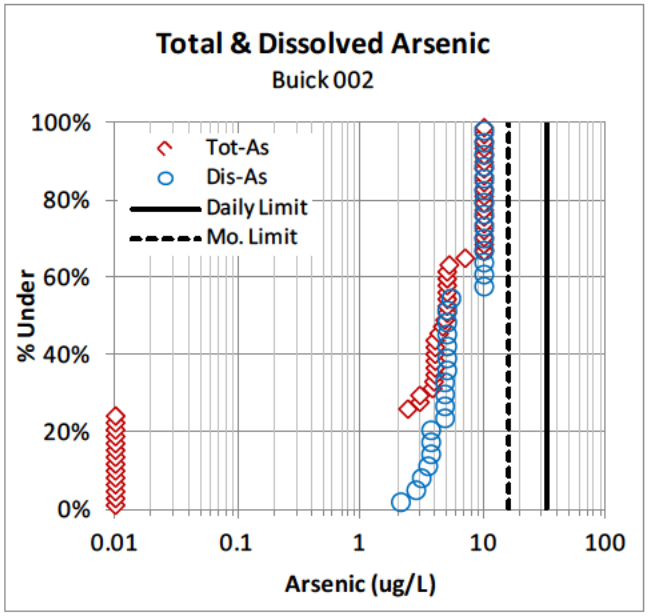


Figure 3-21. Probability Plots for Total and Dissolved Arsenic, Buick002.

Figure 3-22 shows the probability plot for total and dissolved cadmium for outfall 002. The distributions for dissolved and total cadmium indicate a slight difference with respect to the probability of meeting both future final daily and future final monthly limits, but the difference is likely not significant.

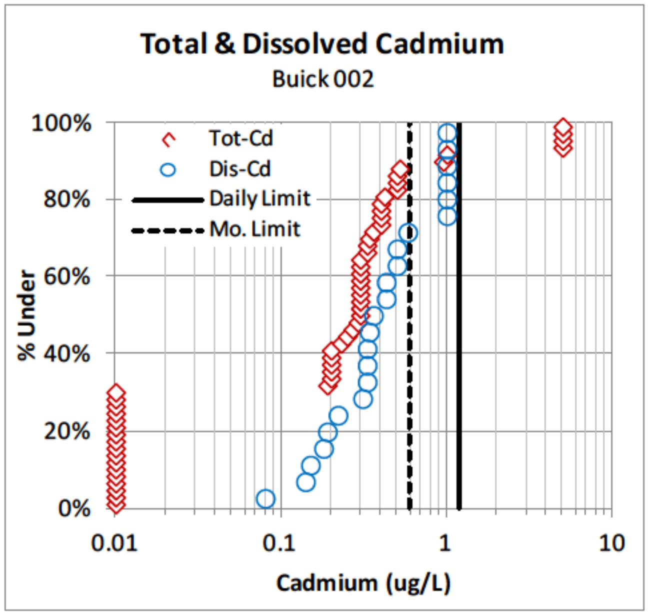


Figure 3-22. Probability Plots for Total and Dissolved Cadmium, Buick002.

The probability plot for total and dissolved copper for outfall 002 is shown in Figure 3-23.

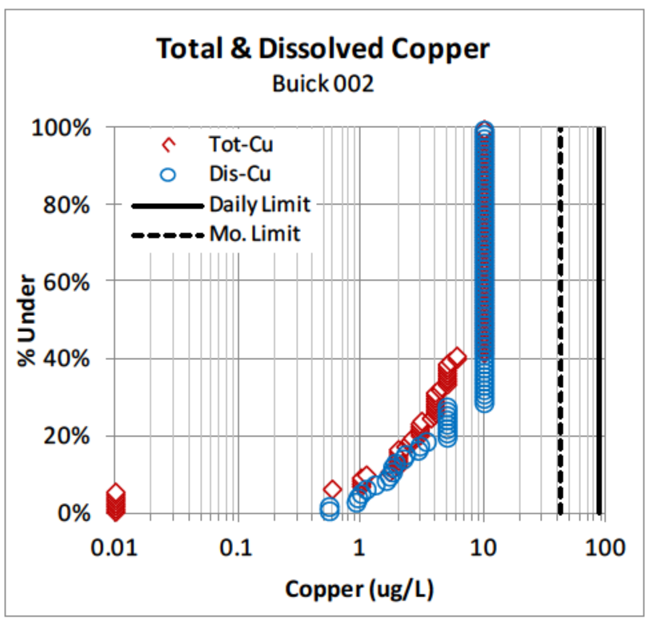


Figure 3-23. Probability Plot for Total and Dissolved Copper, Buick002.

The distributions for dissolved and total copper are very similar and there does not appear to be a significant difference between them with respect to the probability of meeting both future final daily and future final monthly limits. It does not appear that control of either total or dissolved copper at Buick is a significant issue.

Figure 3-24 shows the probability plot for total and dissolved lead for outfall 002.

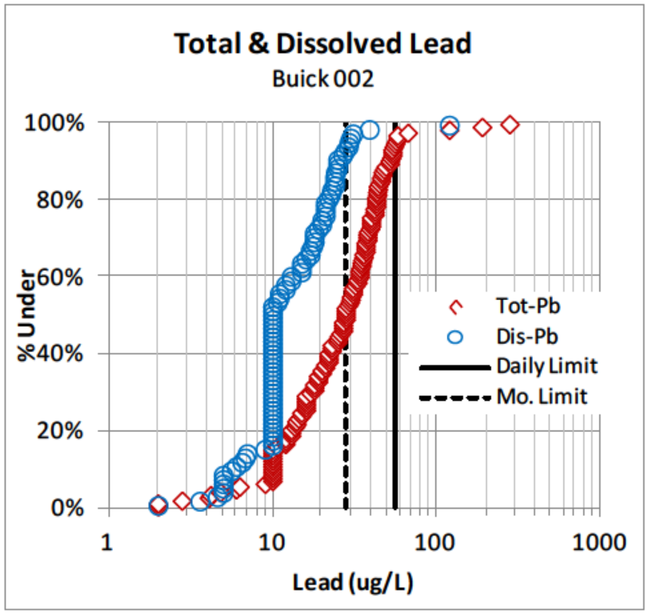


Figure 3-24. Probability Plot for Total and Dissolved Lead, Buick002.

The distributions for dissolved and total lead indicate some difference between them with respect to the probability of meeting future final daily and future final monthly limits. This indicates that control of particulate phase lead is of higher relative importance in attaining future final MSOP limits at Buick.

The probability plot for total and dissolved nickel for outfall 002 is shown in Figure 3-25. The distributions for dissolved and total nickel are nearly identical and there does not appear to be a significant difference between them with respect to the probability of meeting both future final daily and future final monthly limits. These results indicate that both dissolved and total nickel will require control to reliably meet the future final MSOP limits at Buick.

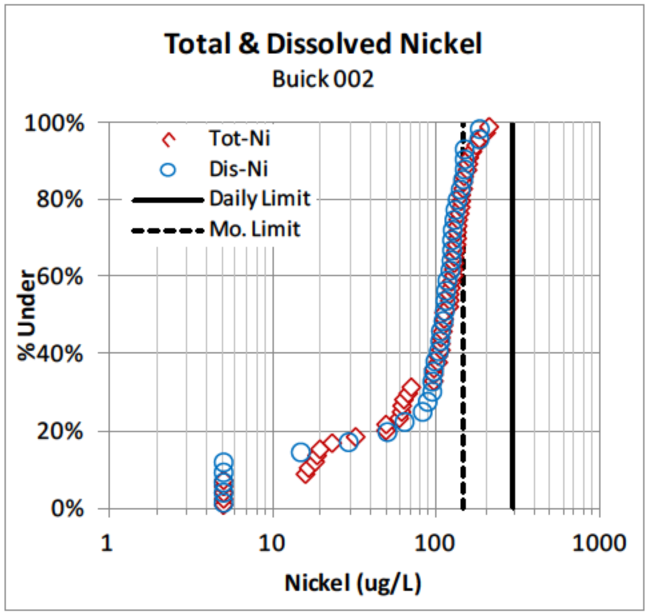


Figure 3-25. Probability Plot for Total and Dissolved Nickel, Buick002.

The probability plots for total and dissolved zinc for outfall 002 are shown in Figure 3-26. The distributions for dissolved and total zinc are nearly identical and both fall above the future final MSOP limits much of the time. These results indicate that both dissolved and total zinc will require control to meet the future final MSOP limits at Buick.

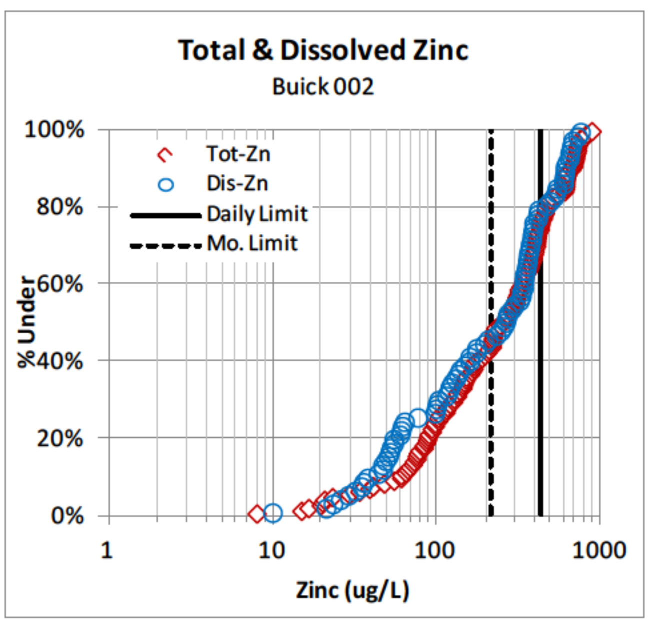


Figure 3-26. Probability Plot for Total and Dissolved Zinc, Buick002.

3.3 SOURCES OF METALS LOADING TO OUTFALLS

As described previously in section 2.1, three major sources of flow to the tailings impoundment at the Buick facility are:

- Mine Water
- Stormwater
- Truck washes

Each of these flows also carries a metals load in water to the tailings impoundment. These loads, as well as their relative importance to effluent quality, are discussed below. It should be noted that the mill process also contributes metals in the water fraction of tailings to the tailings impoundment, but data are not available to quantify this load. This lack of data does not, however, impede water management planning and is addressed in Section 3.4.

3.3.1 Mine Water

As described in Section 2.1.2, mine water is pumped to the surface at the Buick mine water tank under normal operating conditions and flows to the mine water basin from there. Seventeen samples of influent mine water were collected at the mine water tank for use in characterizing mine water for this evaluation (sample location BU-MW). The data from these samples represent the mine water quality coming from the main mine water sump in Buick Mine. Box plots of the total and dissolved metals at BU-MW are presented in Figures 3-27 through Figure 3-31 for cadmium, copper, lead, nickel, and zinc.

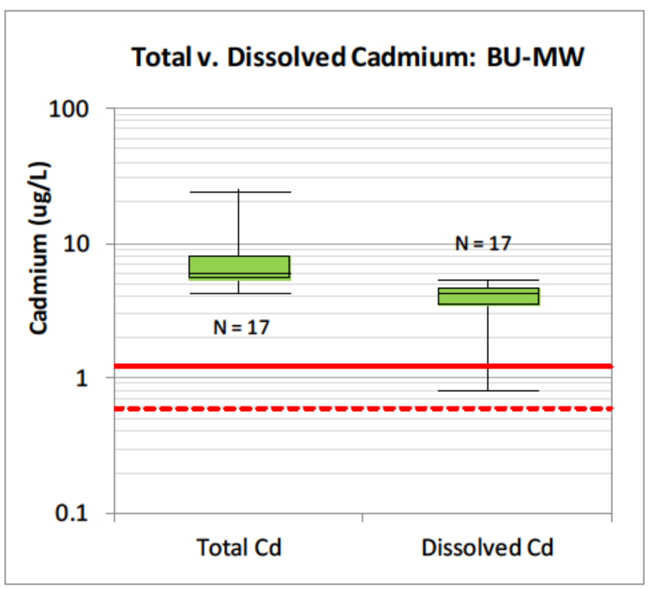


Figure 3-27. Box Plots Comparing Total and Dissolved Cadmium in Influent to the Buick Mine Water Basin.

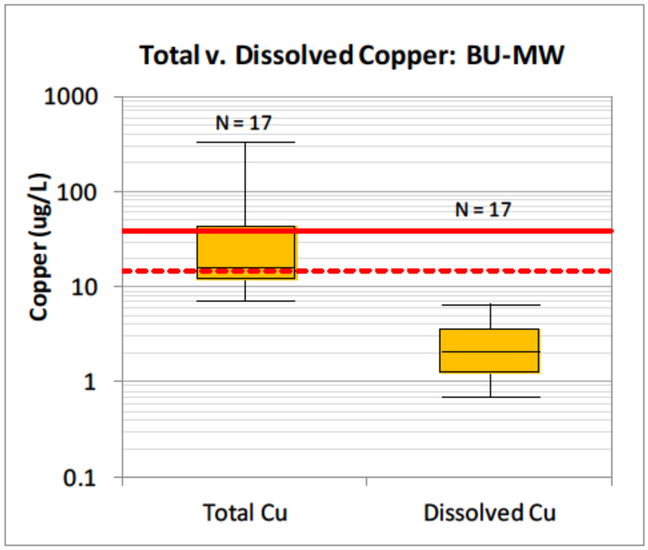


Figure 3-28. Box Plots Comparing Total and Dissolved Copper in Influent to the Buick Mine Water Basin.

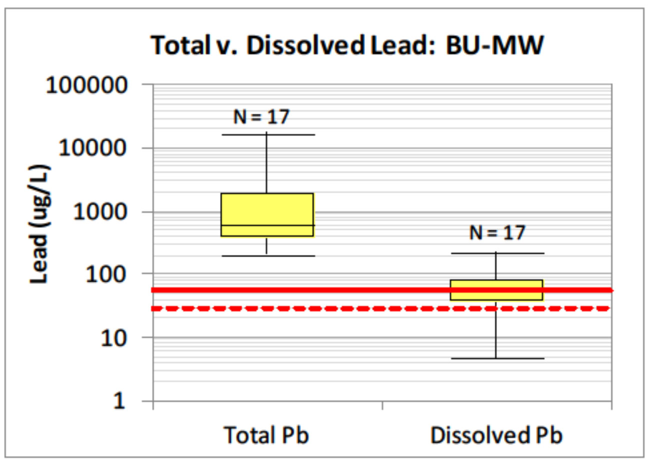


Figure 3-29. Box Plots Comparing Total and Dissolved Lead in Influent to the Buick Mine Water Basin.

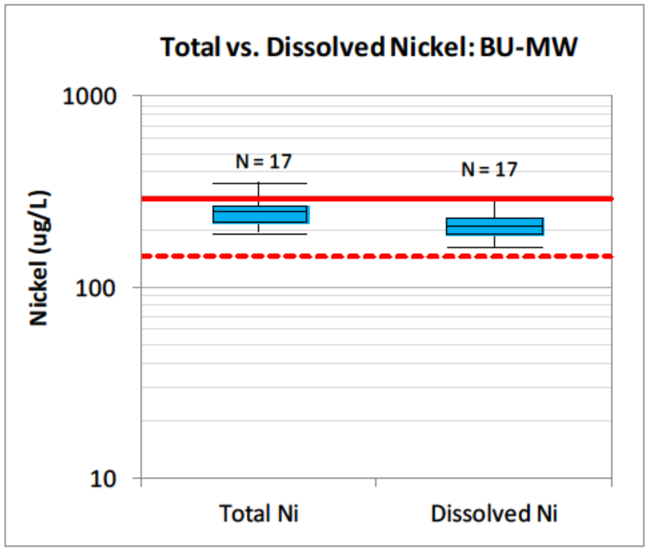


Figure 3-30. Box Plots Comparing Total and Dissolved Nickel in Influent to the Buick Mine Water Basin.

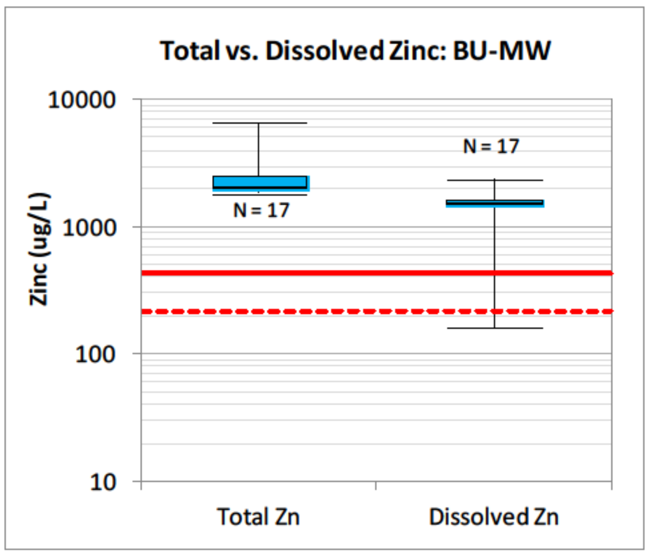


Figure 3-31. Box Plots Comparing Total and Dissolved Zinc in Influent to the Buick Mine Water Basin.

These data support the following observations:

- Results for all incoming mine water samples are higher than both the future final daily maximum and future final monthly average MSOP limits for cadmium, lead and zinc.
- Results for most incoming mine water samples are higher than both the future final daily maximum and future final monthly average MSOP limits for copper and nickel.

- Almost all dissolved cadmium and zinc results in incoming mine water samples are higher than their respective future final daily maximum and future final monthly average MSOP limits.

The average, minimum and maximum concentrations of total metals in influent mine water for the mine water basin are summarized in Table 3-5.

Table 3-5. Average, Minimum and Maximum Concentrations of Total Metals in Mine Water Basin Influent at Buick.

Parameter	Units	Avg. Concentration	Min. Concentration	Max. Concentration
Total Cadmium	µg/L	9	4	25
Total Copper	µg/L	18	7	331
Total Lead	µg/L	583	208	17,200
Total Nickel	µg/L	250	194	357
Total Zinc	µg/L	2,524	1,840	6,610

Average metals loading rates to the mine water basin from mine water were calculated using the average concentrations in Table 3-7 and the average mine water flows discussed in Section 2.2. These calculated average loads can serve as a point of comparison for other potential sources of metals loading, including stormwater runoff and truck wash water. The average calculated loads are presented in Table 3-6.

Table 3-6. Average Calculated Metals Loads in Mine Water at Buick.

Metal	Average Load to Mine Water Basin from Mine Water (kg/yr)
Cadmium	107
Copper	215
Lead	6,960
Nickel	2,980
Zinc	30,130

3.3.2 Stormwater

As noted in Section 2.1.5, significant volumes of stormwater enter the Buick tailings impoundment annually. Although no stormwater runoff samples have been collected at Buick, the metals loading to the mine water basin can be estimated using median concentrations from the National Stormwater Quality Database (NSQD, version 1.1)[7], which is available on-line. That database is a compilation of thousands of

[7] http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/Mainms4paper.html

measurements and the results were evaluated by land use. The land use surrounding the Buick tailings impoundment is forested and the NSQD does not provide results specifically for forested land, it does provide results for undeveloped “open space”. Table 3-7 presents the median concentrations of total cadmium, copper, lead and zinc in stormwater runoff from open space, based on the NSQD, along with the estimate annual loading to the mine water basin and tailings impoundment, based on these concentrations and the annual stormwater flows presented in Section 2.1.5.

Table 3-7. Estimated Metals Loads to Mine Water Basin and Tailings Impoundment at Buick from Stormwater.

Metal	Median Estimated Concentration in Stormwater Runoff (µg/L)	Average Stormwater Load to Mine Water Basin (kg/yr)
Cadmium	0.38	0.24
Copper	10	6.22
Lead	10	6.22
Nickel	8	4.97
Zinc	88	54.7

3.3.3 Truck Washes

The influent to the Buick tailings impoundment from the truck washes were evaluated to assess the relative impact of these sources on water quality at mine water outfall 002. One sample was collected from the con truck wash discharge (2/16/11) and two samples of ore truck wash discharge were collected (2/16/11 and 6/17/11). Each set of results were compared to the incoming mine water for those dates to assess the relative concentrations of metals. The 2/16/11 sampling results are presented in Table 3-8 and depicted graphically in Figure 3-32.

Table 3-8. Concurrent Sampling Results for Truck Wash and Mine Water Locations- 2/16/11.

Parameter	Units	BU-MW	BU-ConTrkWshEff	BU-OreTrkWshEff
Cadmium	µg/L	6	7.5	14.5
Copper	µg/L	16.9	21.8	216
Lead	µg/L	758	1,140	8,270
Nickel	µg/L	232	225	249
Zinc	µg/L	1,980	2,340	2,590
TSS	mg/L	6	35	191

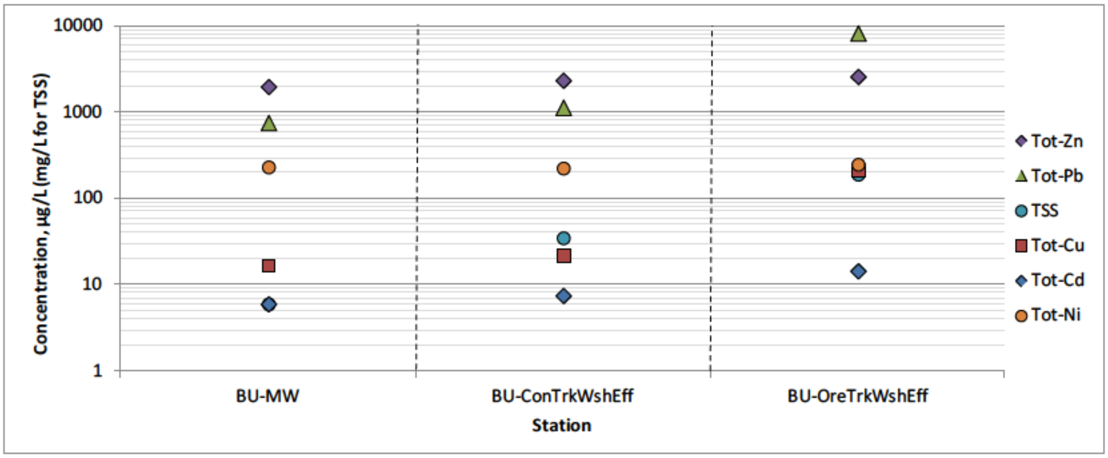


Figure 3-32. Sampling Results for Total Metals and Solids in Truck Wash and Mine Water Locations– 2/16/11.

The 6/17/11 sampling results are presented in Table 3-9 and depicted graphically in Figure 3-33.

Table 3-9. Concurrent Sampling Results for Truck Wash and Mine Water Locations- 6/17/11.

Parameter	Units	BU-MW	BU-OreTrkWshEff
Total Cadmium	µg/L	5.7	10
Total Copper	µg/L	7.1	173
Total Lead	µg/L	583	9,062
Total Nickel	µg/L	194	228
Total Zinc	µg/L	2,118	2,488
TSS	mg/L	12	243

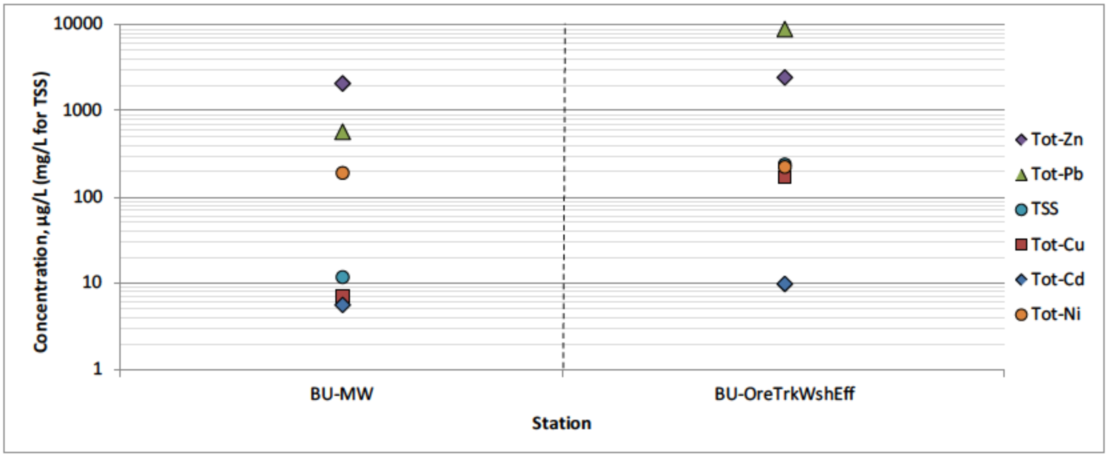


Figure 3-33. Sampling Results for Total Metals and Solids in Truck Wash and Mine Water Locations– 6/17/11.

The truck wash discharge data can be used in conjunction with the flow estimates developed in Section 2.1.6, to calculate metals loading estimates for the Buick truck washes. The average results from the two sampling events for the ore truck wash were used to calculate the ore truck wash load; the results of the single event for the con truck wash discharge was used for the con truck load. These estimates are presented in Table 3-10. Comparison of the truck wash load estimates in Table 3-10 with the load estimates for mine water presented in Table 3-6, show that mine water contributes a significantly higher load of metals than the truck wash.

Table 3-10. Average Metals Loads to Buick Mine Water Basin from Truck Washes.

Metal	Average Load to Tailings Impoundment from Ore Truck Wash (kg/yr)	Average Load to Tailings Impoundment from Con Truck Wash (kg/yr)
Cadmium	1.7	0.1
Copper	26.9	0.3
Lead	1,197	15.7
Nickel	32.9	3.1
Zinc	351	32.3

3.4 SOURCE ASSESSMENT SUMMARY

The analysis of the three sources of metals in water to the tailings impoundment described above, support the following observations:

- Of the three sources evaluated, mine water is the largest source of metals loading to water in the tailings impoundment, accounting for 85% to 99% of the total metal load, depending on the metal.
- It is unlikely that reduction of metals concentrations in stormwater runoff or truck wash water will have a significant effect on water quality at outfall 002.

Figures 3-34 through 3-38 show the relative distributions of these sources to the Buick tailings impoundment for total cadmium, total copper, total lead, total nickel and total zinc.

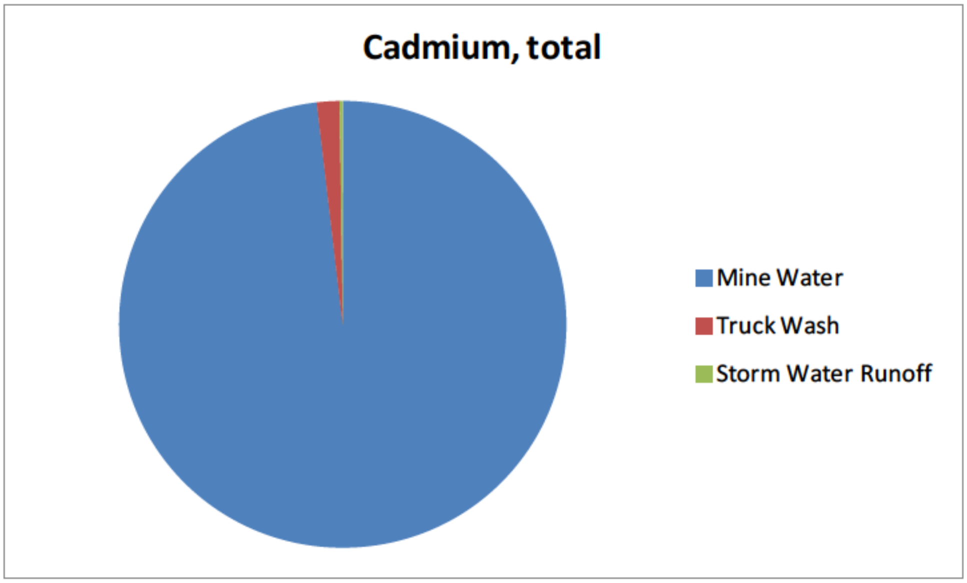


Figure 3-34. Relative Distribution of Total Cadmium Load Sources to the Buick Tailings Impoundment[8].

[8] It should be noted that this comparison does not include metals loading from tailings. Tailings enter the tailings impoundment as a slurry and the aqueous component of the tailings will have a metals content at least equal to, if not greater than, mine water. Therefore, the loading comparison shown here and the loading comparisons shown on the following pages are conservative; if the metals loading from tailings was included, the relative contribution of metals loading from storm water and truck washes would be even smaller.

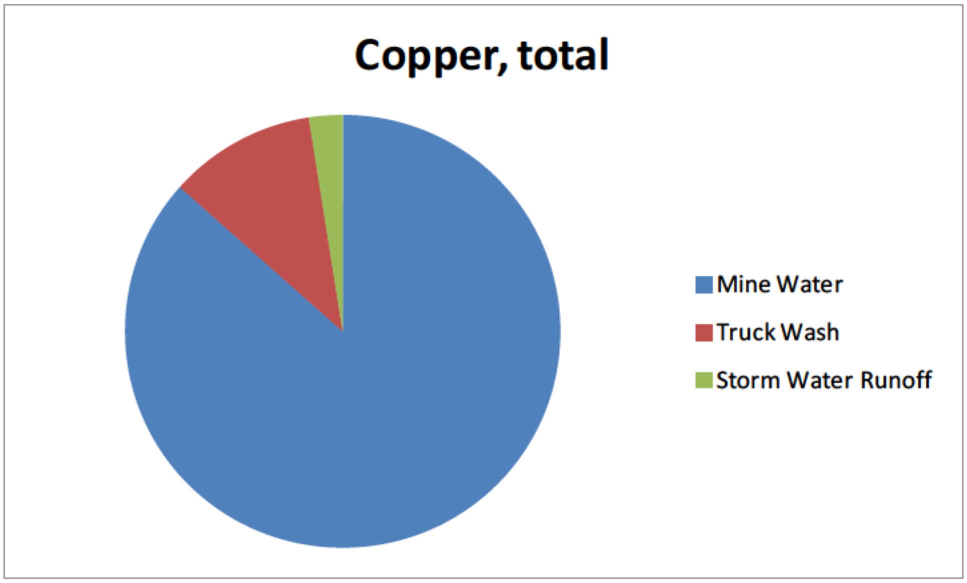


Figure 3-35. Relative Distribution of Total Copper Load Sources to the Buick Tailings Impoundment.

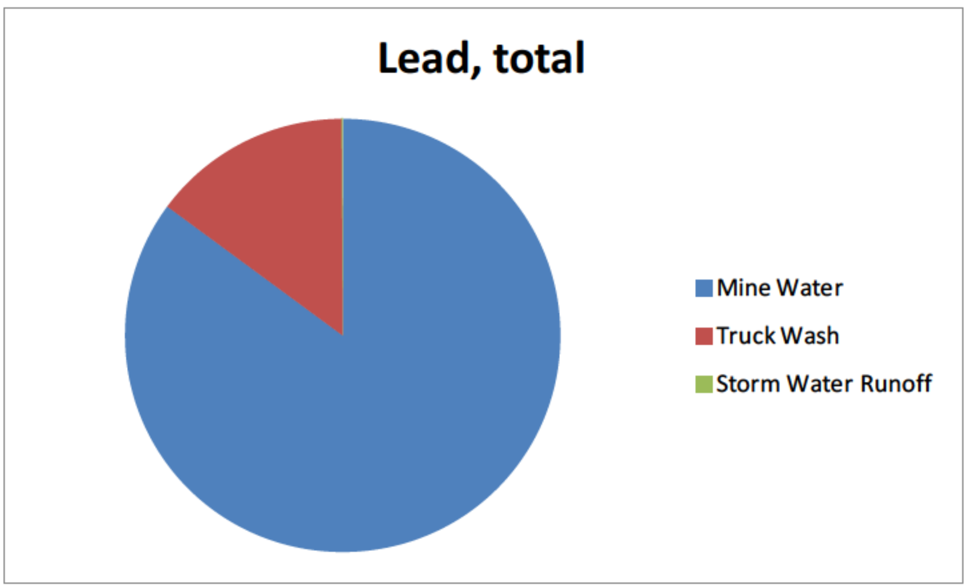


Figure 3-36. Relative Distribution of Total Lead Load Sources to the Buick Tailings Impoundment.

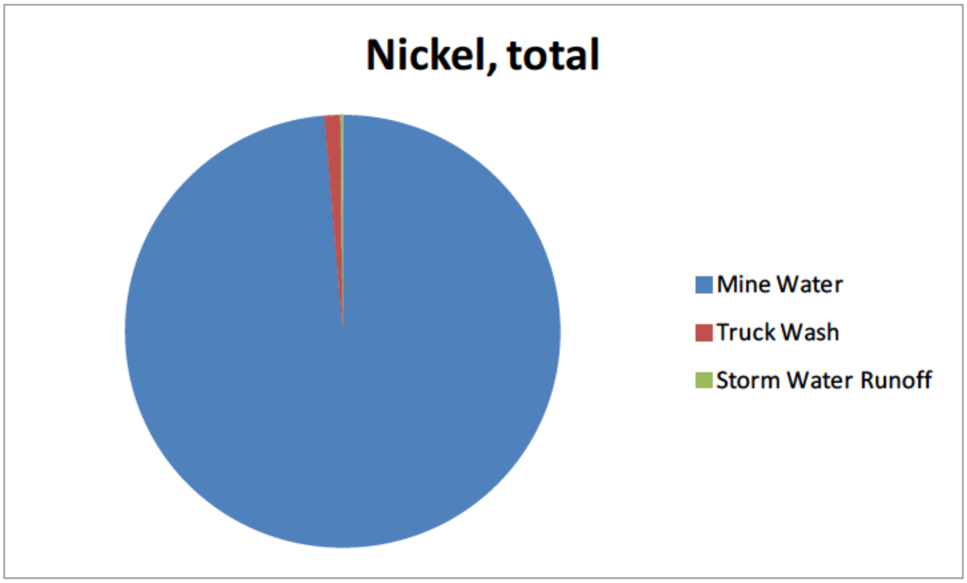


Figure 3-37. Relative Distribution of Total Nickel Load Sources to the Buick Tailings Impoundment.

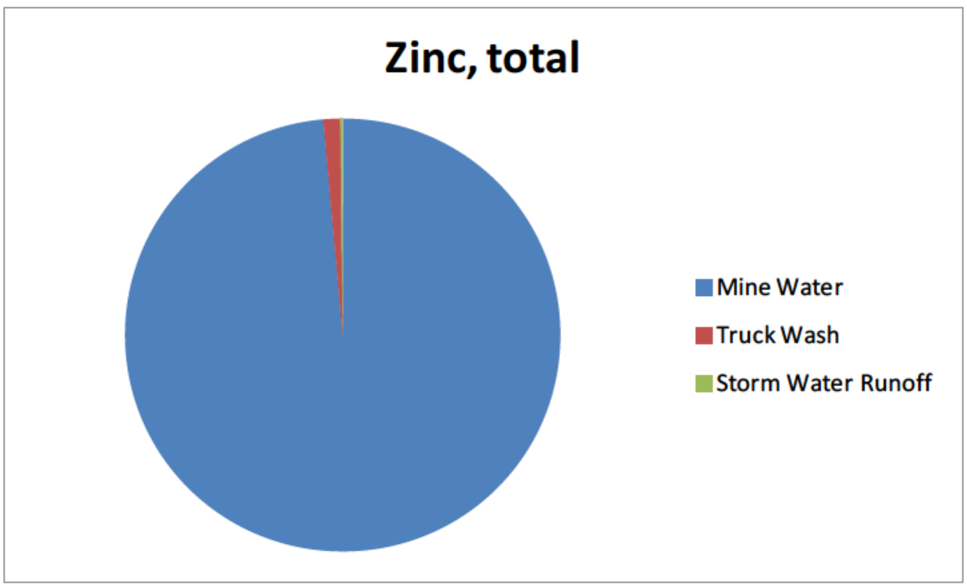


Figure 3-38. Relative Distribution of Total Zinc Load Sources to the Buick Tailings Impoundment.

Because mine water is the dominant source of metals loading to water in the tailings impoundment, further significant reduction in metals concentrations at the outfall may be achieved by improving the level of water treatment before mine water reaches the tailings impoundment, within the tailings impoundment, or between the tailings impoundment and outfall 002.

4. FATE AND TRANSPORT EVALUATION

To understand and evaluate potential control measures for reducing metals concentrations at Buick outfall 002, it is necessary to define the major fate and transport processes that affect metals in water before it reaches the outfalls. This section of the SWMP identifies the significant fate and transport processes affecting water quality at the outfall and provides an evaluation of those processes to support identification of control measures.

4.1 IDENTIFICATION OF POTENTIAL FATE AND TRANSPORT PROCESSES AFFECTING OUTFALL WATER QUALITY AT BUICK

As stated in Section 3 of this plan, mine water is the major source of metals loading to outfall 002 and loading from other sources (stormwater runoff and truck wash water) appears to have little or no effect on effluent quality from the tailings impoundment. Therefore, the goal of meeting future final MSOP limits at the Buick facility may be met by reducing metals concentrations in mine water. At Buick, mine water is pumped to the surface and discharged into the mine water basin where it subsequently flows to the tailings impoundment. This being the case, the fate and transport processes that affect metals in mine water before discharge are the processes within the mine water basin and the tailings impoundment, including the following:

- Solids settling – Metals already complexed with suspended solids can settle out of suspension. This process results in a decrease in metals concentration between the mine water influent and the outfall, accompanied by a decrease in TSS between these locations.
- Solids resuspension – This is the opposite of settling; solids on the bed of the impoundment may be resuspended into the water column by hydrodynamic or wind-driven energy.
- Adsorption to solids – Metals are adsorbed to solids on the bed of the impoundment or to organic (algal) solids in the water column. This may result in a decrease in dissolved metals concentrations between the mine water influent and the outfall.

The fate of metals in mine water between the mine water tank and outfall 002 are discussed in the following sections.

4.2 CHANGES IN MINE WATER QUALITY THROUGH MINE WATER BASIN AND TAILINGS IMPOUNDMENT

As discussed previously, mine water is pumped to the surface at Buick into the mine water tank and from there it flows into the mine water basin, then into the tailings impoundment and then through the meander system and clear water basin to outfall 002. Data from key locations in this flow path were reviewed to assess where major changes in water quality occur, with respect to total metals. MSOP effluent limits are included in the plots to facilitate comparison of effluent concentrations with applicable effluent standards. These results are depicted graphically in Figures 4-1 through 4-5.

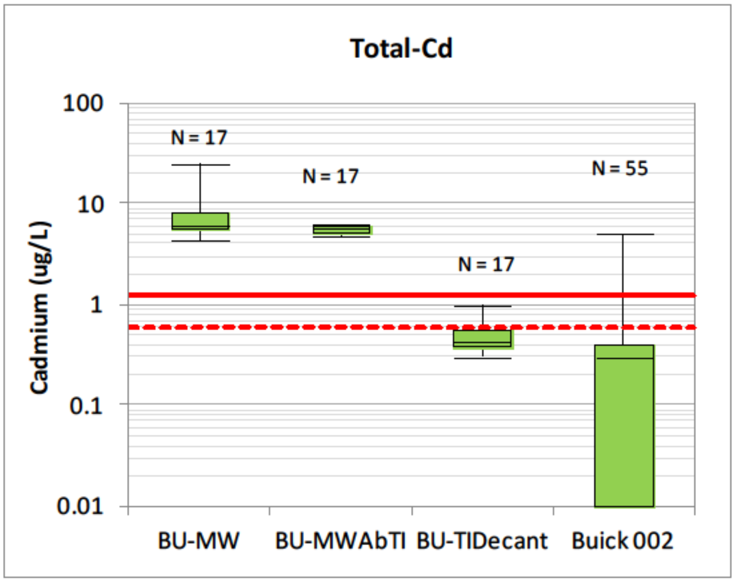


Figure 4-1. Comparison of Total Cadmium[9] Concentration From Buick Mine Water Basin to Outfall 002.

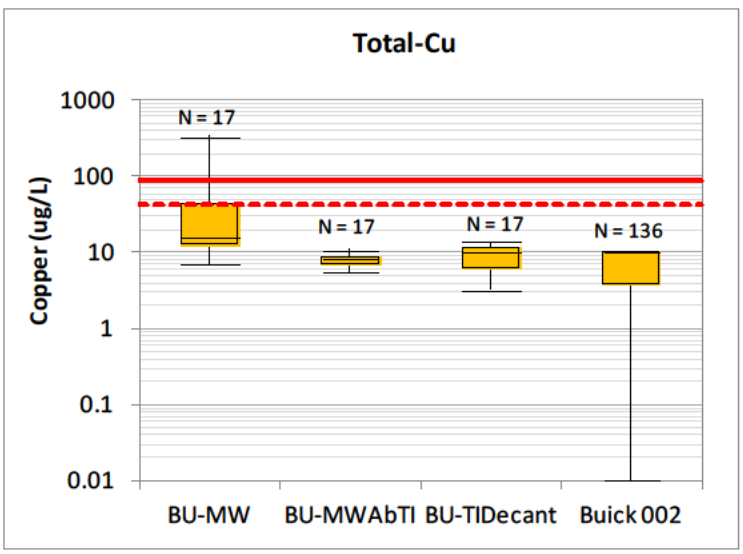


Figure 4-2. Comparison of Total Copper Concentration From Buick Mine Water Basin to Outfall 002.

[9] As discussed previously, the total cadmium plots use data measured at the target locations between June 2010 and April 2012. This time period was selected because prior to June 2010, detection limits of both 5 µg/L and 10 µg/L were used for cadmium. Consequently, most samples were non-detect and would not add value in comparing the data to MSOP effluent limits (all effluent limits are below 5 µg/L).

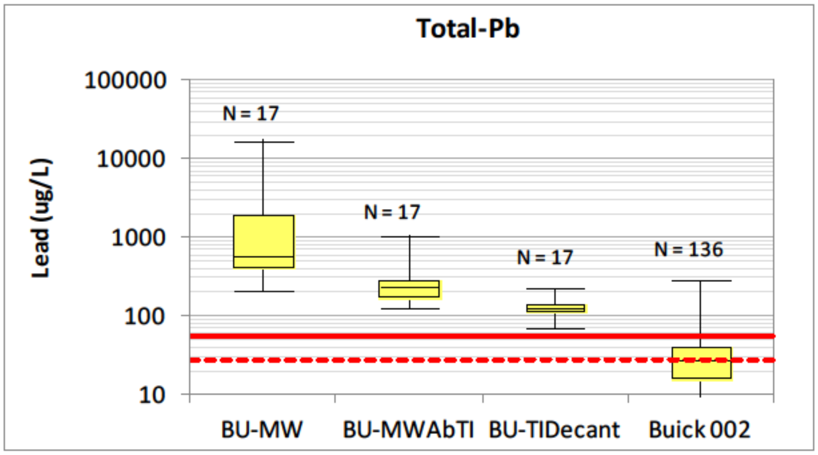


Figure 4-3. Comparison of Total Lead Concentration From Buick Mine Water Basin to Outfall 002.

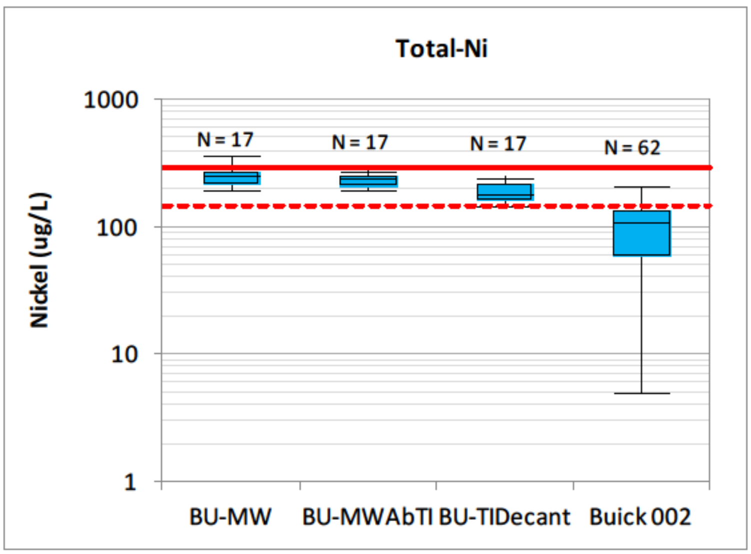


Figure 4-4. Comparison of Total Nickel Concentration From Buick Mine Water Basin to Outfall 002.

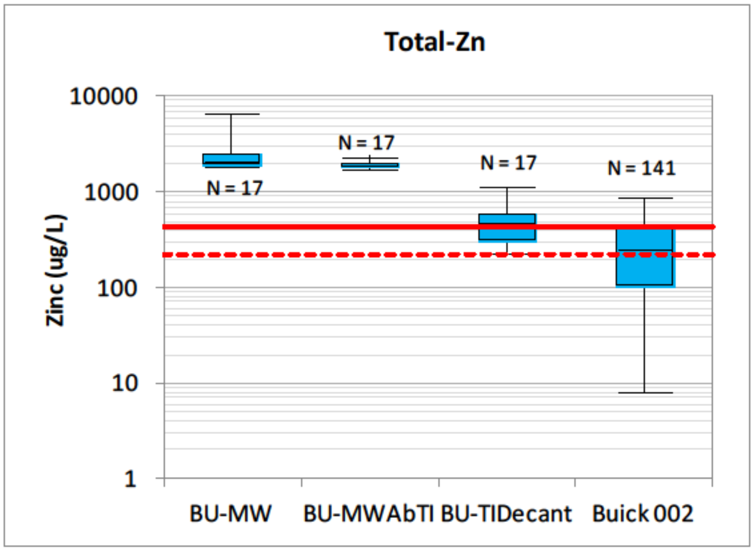


Figure 4-5. Comparison of Total Zinc Concentration From Buick Mine Water Basin to Outfall 002.

Table 4-1 summarizes the average concentrations calculated for each parameter at BU-MW and outfall 002, as well as the decrease in concentration based on the change in average concentration.

Table 4-1. Change in Average Total Metals and TSS Concentrations Between Influent and Effluent in Buick Mine Water Basin.

Parameter	Units	Average Concentration		Decrease	Percent
		BU-MW	BU-002	in Concentration	Decrease
Total Cadmium	µg/L	8.7	0.6	8.1	93%
Total Copper	µg/L	47.9	7.0	40.9	85%
Total Lead	µg/L	2,991	32	2,959	99%
Total Nickel	µg/L	256.6	100.1	156.5	61%
Total Zinc	µg/L	2,525	304	2,221	88%
Total Suspended Solids	mg/L	20.1	3.0	17.1	85%

Comparing the changes in average concentrations of target parameters along the flow path from the Buick mine water basin to outfall 002 (as depicted in Figures 4-1 through 4-5), the following observations can be made:

- Significant reductions in concentrations are observed for all metals between the mine water tank and outfall 002.
- Total lead and total cadmium show the largest reductions of 99% and 93%, respectively.
- Total nickel experiences the lowest reduction of 61%.

- Removal rates vary by metal species along the flow path. For example:
    - Concentrations of total cadmium, total nickel and total zinc are only slightly reduced in the Buick mine water basin, compared to total copper and total lead. Total copper, total lead and TSS show the largest reduction in average concentration across the mine water basin, between 73% and 88%. Total nickel and zinc shows the lowest reductions in the mine water basin of 9% and 24% respectively.
    - The Buick tailings impoundment provides removal of most total metals concentrations from mine water, with the exception of copper. Total cadmium and zinc show the largest reduction (91% and 74%, respectively) in average concentration across the tailings impoundment.

Because most of the metals removal appears to occur in the tailings impoundment, the processes occurring in the impoundment are examined in greater detail below.

4.3 WATER QUALITY WITHIN THE TAILINGS IMPOUNDMENT

Water in the tailings impoundment was sampled at 4 locations on 4/19/11 to evaluate spatial differences in water quality. Samples were collected from the surface and near the bottom of the water column and were analyzed for total and dissolved metals as well as total suspended solids. The results for total cadmium, total copper, total lead, total nickel, total zinc, and total suspended solids are shown in Figure 3-34.

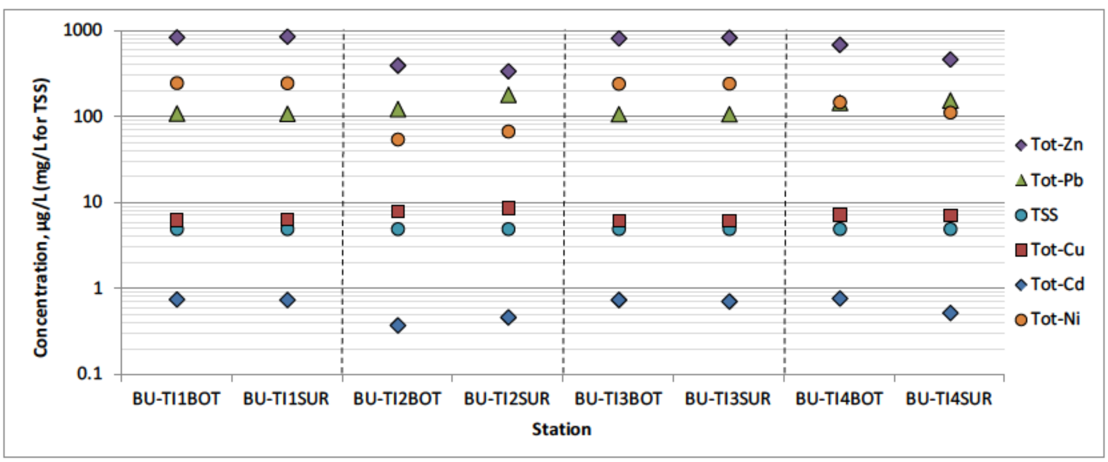


Figure 4-6. Tailings Impoundment Total Metals Results 4/19/11.

The results for dissolved cadmium, dissolved copper, dissolved lead, dissolved nickel, and dissolved zinc are shown in Figure 4-7.

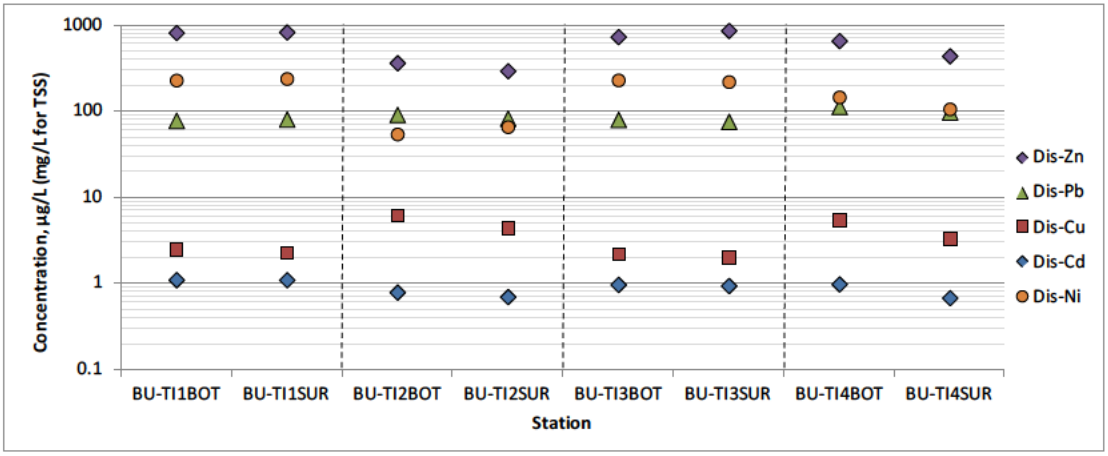


Figure 4-7. Tailings Impoundment Dissolved Metals Results 4/19/11.

These data show some spatial variability in metals concentrations within the tailings impoundment, but there is no clear pattern and it is difficult to draw any conclusions from a single sampling event.

4.4 SEASONAL VARIABILITY IN EFFLUENT QUALITY

In Section 3.2.2 of this plan, some apparent seasonal variability in water quality at outfall 002 was observed when the outfall data were plotted by month. In addition, the time series plots of outfall data presented in Section 3.2.1 also appear to show a somewhat regular pattern of highs and lows for total zinc and, to a lesser degree, total lead and total nickel. If these data are plotted as lines instead of data points, the pattern is clearer, as shown in Figure 4-8 for total metals and Figure 4-9 for dissolved metals.

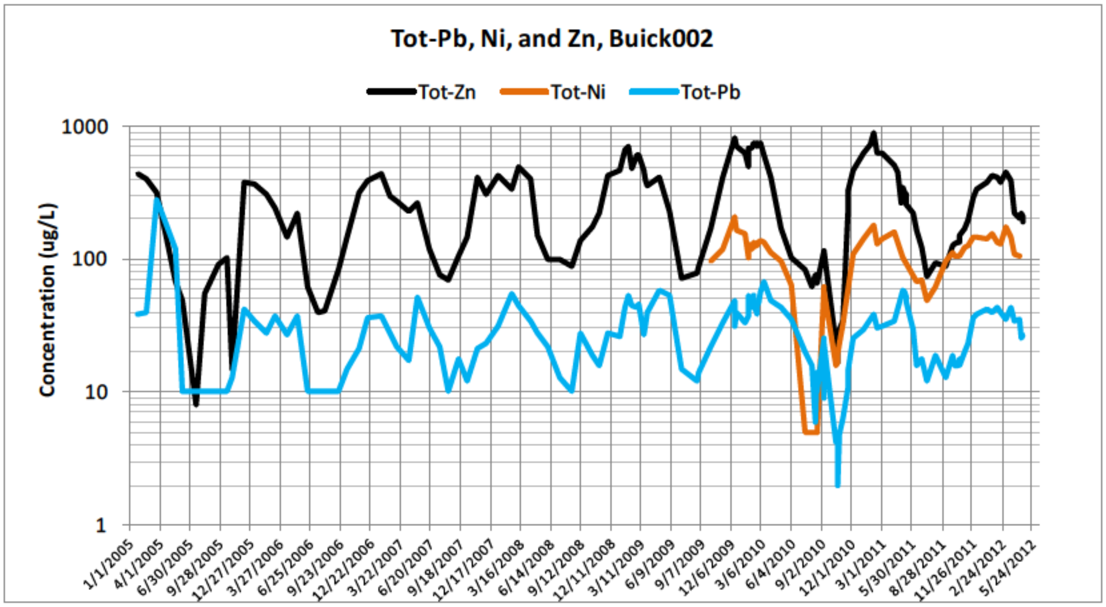


Figure 4-8. Time Series Pattern of Total Lead, Total Nickel and Total Zinc at Buick Outfall 002.

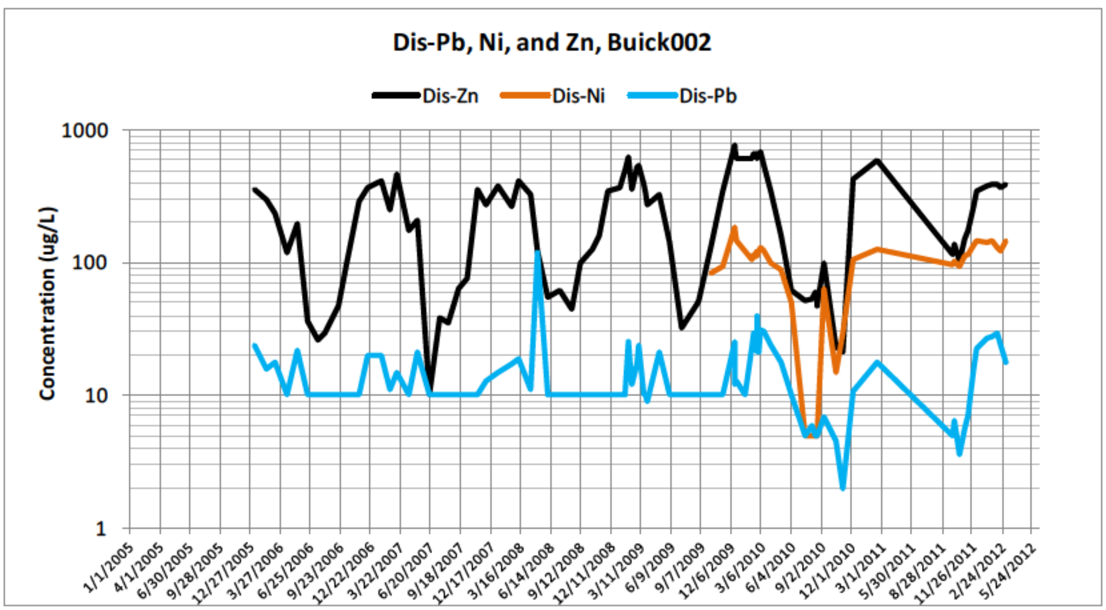


Figure 4-9. Time Series Pattern of Dissolved Lead, Dissolved Nickel and Dissolved Zinc at Buick Outfall 002.

These plots show an apparent annual cycle in water quality that is most evident in total and dissolved zinc, and less pronounced for lead and nickel. The pattern appears to be that concentrations in these metals are generally much lower at outfall 002 in late summer and early fall (July through October) than in other parts of the year. When the outfall data are compared to future final effluent limits on a monthly basis, the future final effluent limits have never been exceeded in these months. Figure 4-10 shows the number of samples that were higher than the future final monthly average limits for total lead, nickel and zinc at outfall 002.

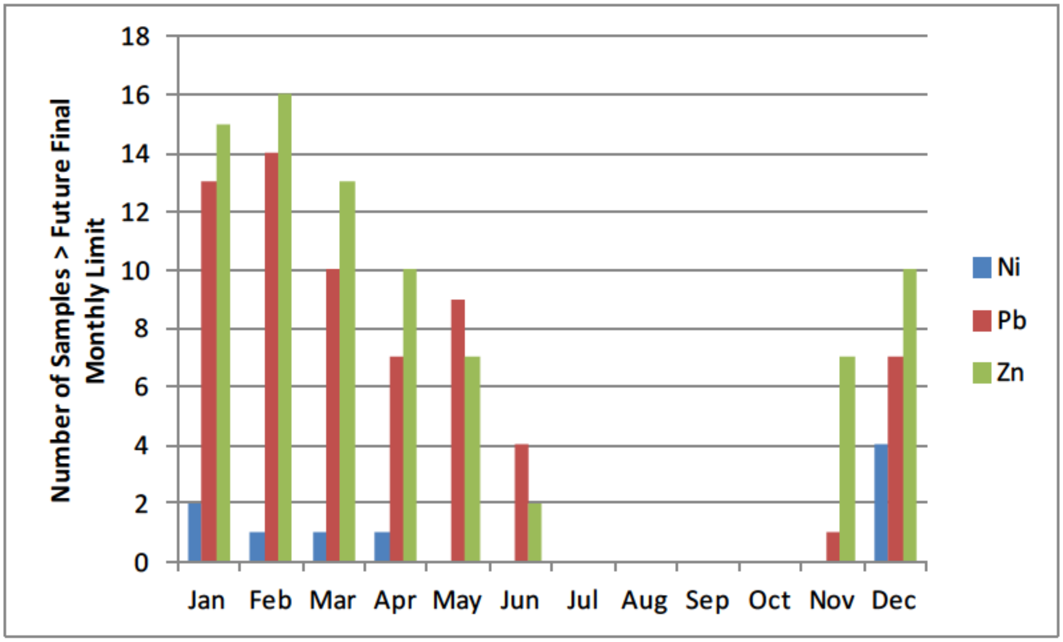


Figure 4-10. Sample Results Above Future Final Monthly Average Effluent Limits for Total Lead, Nickel and Zinc at Buick Outfall 002.

The results presented above clearly indicate that water quality at outfall 002 varies during the year on a regular basis and that variation has a significant impact on attainment of the future final effluent limits at outfall 002.

There are two processes that can potentially explain the observed seasonal variation in effluent quality:

1. Resuspension of settled tailings solids – The higher total metals at outfall 002 from November through June occurs during the same months when precipitation is higher and more flow passes through the tailings impoundment as a result. This higher flow could cause greater resuspension of settled tailings solids. If this was the cause of the observed seasonal variability, however, there should be a significant corresponding seasonal variability in TSS at the outfall, which is not apparent in the data. Furthermore, it would not explain the variability in dissolved metals, especially zinc.

2. Sorption to organic solids and subsequent settling – It is possible that algal growth is occurring in the tailings impoundment during the summer and dissolved metals are sorbed to the organic algal solids which then die and settle out of the water column, along with the sorbed metals. This would explain why the seasonality is most pronounced for zinc, which has a higher dissolved fraction and shows a stronger seasonal pattern.

If sorption to organic solids in the water column is the cause of the seasonal variability in water quality at outfall 002, a decrease in dissolved metals concentrations between the incoming mine water and the mine water at the outfall would be expected. Box plots comparing the dissolved metals concentrations between the mine water entering the tailings impoundment and the outfall are presented in Figures 4-11 through 4-15 for dissolved cadmium, copper, lead, nickel, and zinc.

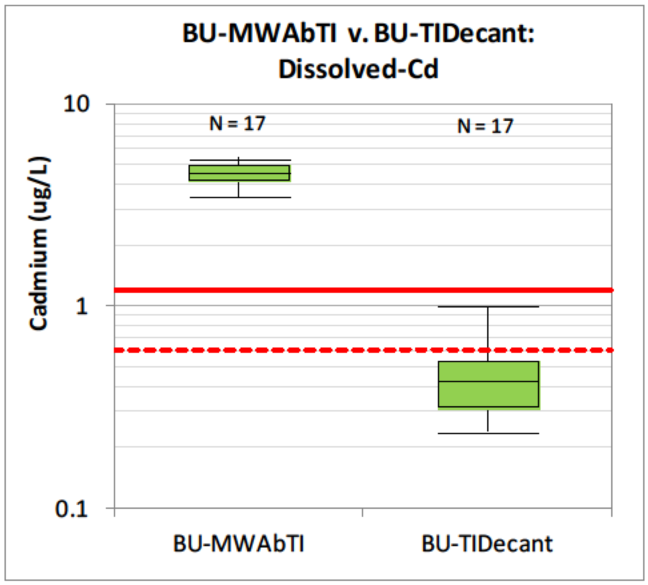


Figure 4-11. Comparison of Dissolved Cadmium Concentration Entering and Leaving Buick Tailings Impoundment.

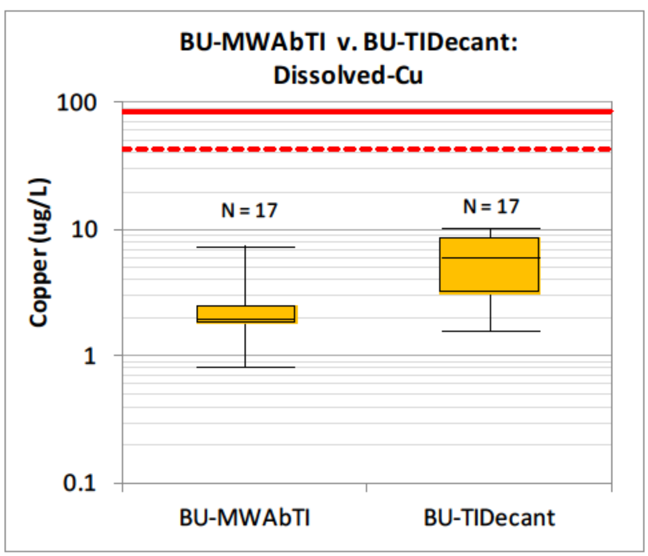


Figure 4-12. Comparison of Dissolved Copper Concentration Entering and Leaving Buick Tailings Impoundment.

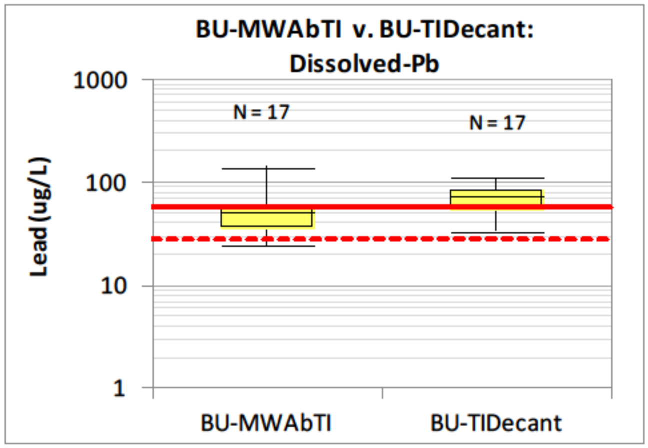


Figure 4-13. Comparison of Dissolved Lead Concentration Entering and Leaving Buick Tailings Impoundment.

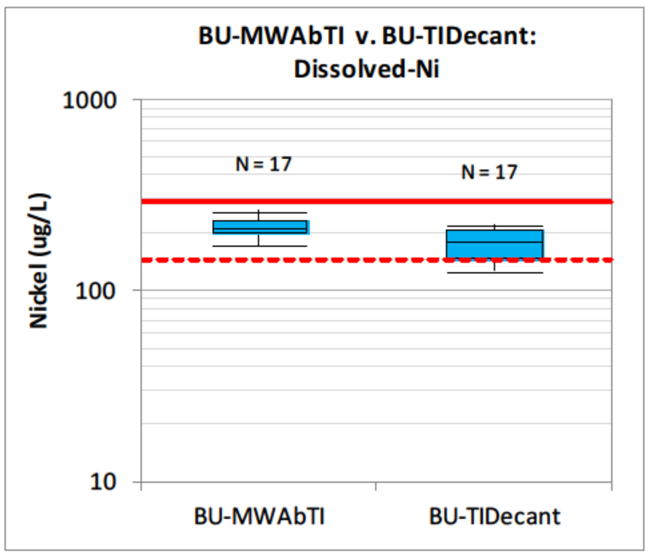


Figure 4-14. Comparison of Dissolved Nickel Concentration Entering and Leaving Buick Tailings Impoundment.

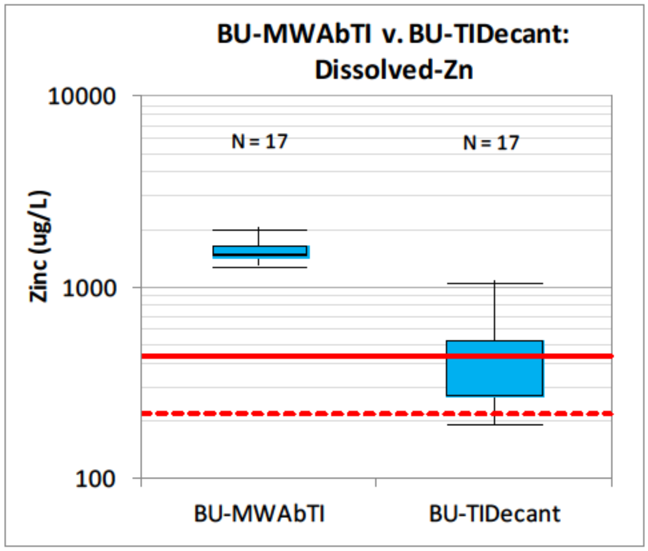


Figure 4-15. Comparison of Dissolved Zinc Concentration Entering and Leaving Buick Tailings Impoundment.

The comparisons of dissolved metals shown above support the following observations:

- There appears to be a significant decrease in dissolved cadmium and dissolved zinc between the incoming mine water and the mine water leaving the tailings impoundment.
- There does not appear to be a decrease in dissolved copper, lead, or nickel between the incoming mine water and the mine water leaving the tailings impoundment.

These results indicate that the seasonal variability in total zinc at outfall 002 may be attributed to sorption to organic solids in the water column, but this cannot be definitively concluded at this time.

4.5 WATER QUALITY CHANGE IN THE MEANDER SYSTEM/CLEAR WATER BASIN

The data plotted in figures 4-1 through 4-5 indicates that additional metals removal is occurring between the tailings impoundment and the outfall, as water flows through the Buick meander system and clear water basin, particularly for lead, nickel and zinc. The meander system and clear water basin, downstream of the Buick tailings dam, were designed to provide opportunity for additional removal of metals through extended contact in the meander and additional settling in the clear water basin.

The change in water quality between the tailings impoundment decant structure and outfall 002 show that the meander system and clear water basin are providing additional treatment. In addition, samples were collected at the tailings impoundment discharge (BU-TIDis) and clear water basin discharge (BU-CWEff) locations on

2/16/11 and 6/14/11 to evaluate removal performance. The sample results are shown in Figures 4-16 and 4-17.

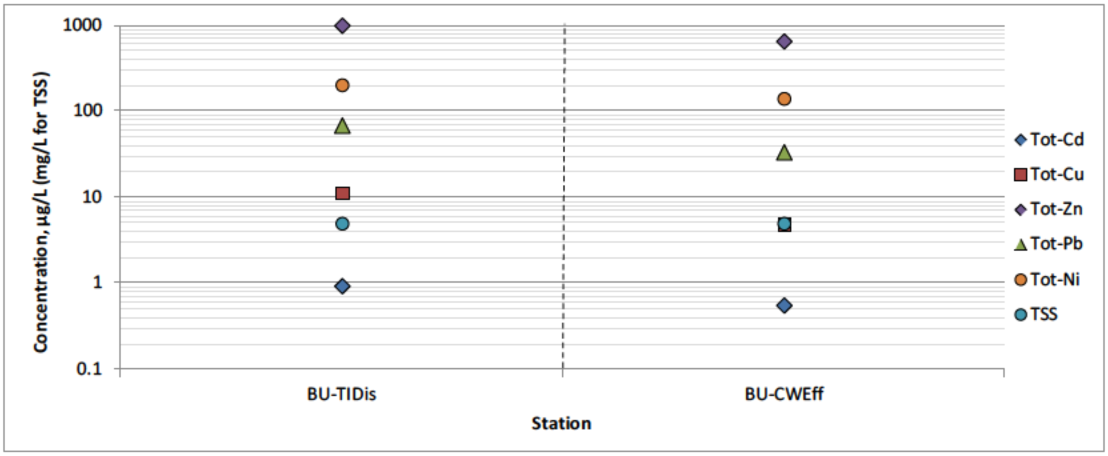


Figure 4-16. Total Metals at Tailing Impoundment Discharge and Clear Water Basin Discharge Locations on 2/16/11.

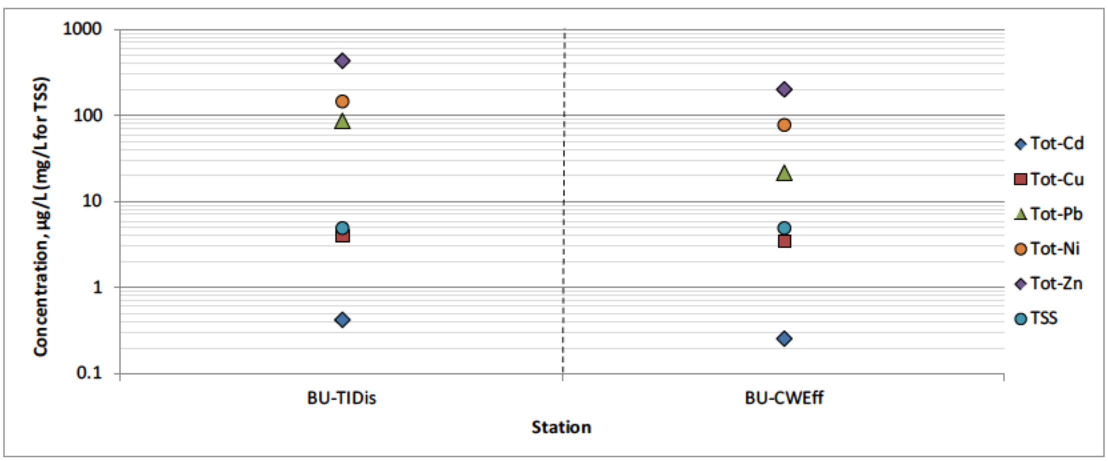


Figure 4-17. Total Metals at Tailing Impoundment Discharge and Clear Water Basin Discharge Locations on 6/14/11.

Table 4-2 summarizes the average concentrations calculated for each parameter at BU-TIDis and BU-CWEff, as well as the decrease in concentration based on the change in average concentration for the two sets of samples.

Table 4-2. Change in Average Total Metals Concentrations Entering and Leaving Buick Meander System (based on samples collected on 2/16/11 and 6/17/11).

Parameter	Units	Average Concentration		Decrease in Concentration	Percent Decrease
		BU-TIDis	BU-CWEff		
Total Cadmium	µg/L	0.69	0.41	0.28	40%
Total Copper	µg/L	7.7	4.2	3.5	45%
Total Lead	µg/L	79	28	51	65%
Total Nickel	µg/L	176	110	66	37%
Total Zinc	µg/L	719	429	290	40%

The two sampling events at BU-TIDis and BU-CWEff appear to corroborate the reductions in metals concentrations observed in comparing the decant structure data with the outfall data (Figures 4-1 through 4-5).

4.6 FATE AND TRANSPORT PROCESS SUMMARY FOR METALS IN BUICK MINE WATER BASIN, TAILINGS IMPOUNDMENT, MEANDER SYSTEM, AND CLEAR WATER BASIN

The preceding analysis and discussion can be summarized by the following findings:

- The Buick mine water basin provides effective settling of TSS.
- Significant reductions in concentrations are observed for all metals between the mine water tank and outfall 002.
- There is a seasonal pattern in zinc, nickel, and lead concentrations at outfall 002 that may be attributed to sorption to organic solids in the water column, but this cannot be definitively concluded without further investigation.
- Limited sampling of mine water entering and leaving the meander system and clear water basin appear to indicate that metals concentrations are reduced through the system.

These findings will inform the evaluation of potential water management measures for the Buick facility.

This page is blank to facilitate double sided printing.

5. POTENTIAL WATER MANAGEMENT MEASURES

Potential water management issues to improve effluent quality and attain future final MSOP limits are identified in this section. As stated in the Master SWMP (LimnoTech, 2011a), a hierarchy has been established as a tool for use when water management solutions are evaluated during development of Site-Specific SWMPs. The hierarchy sets priorities for the management of regulated water at Doe Run facilities and is presented in Figure 5-1.

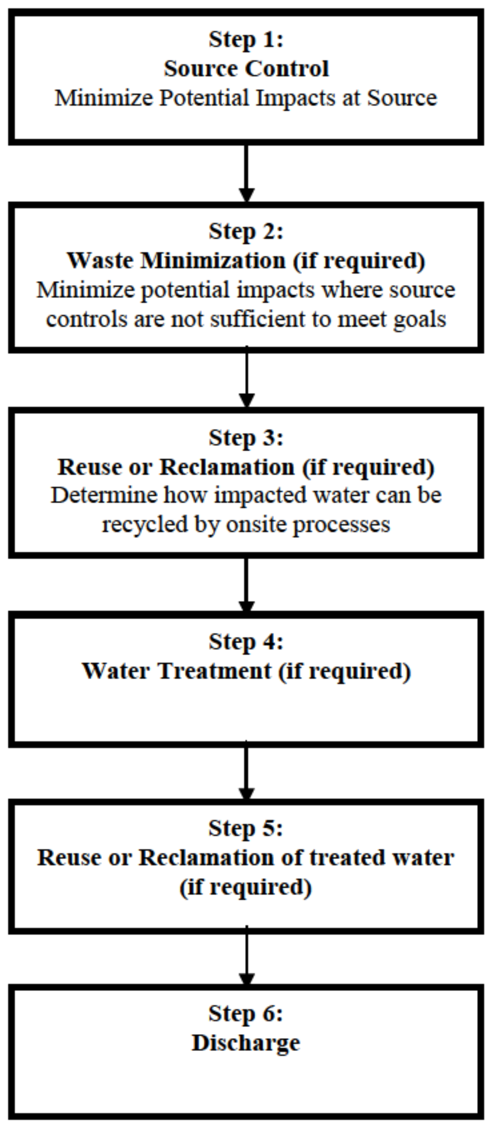


Figure 5-1. Hierarchy of Water Management Priorities

The water management hierarchy shown in Figure 5-1 establishes source control or pollution prevention through the implementation of Best Management Practices

(BMPs) as a top priority. BMPs can also support waste minimization. The hierarchy lists water treatment but in addition to treatment, the Master SWMP also states that alternative discharge practices will be evaluated. Based on this information from the Master SWMP, the identification of potential water management measures is organized as follows:

- Best management practices (source control)
- Waste minimization
- Water reuse or reclamation
- Water treatment
- Alternative discharge practices

Each of these categories of potential water management measures is discussed below.

5.1 BEST MANAGEMENT PRACTICES

The water management hierarchy places the highest priority on source control which, in the context of the Buick SWMP, means either reduction of the volume of water being discharged or the concentration of metals in the effluent from the mine water basin. The major flow volume through the mine water basin is mine water, as discussed in Section 2, and the Underground Water Management Plan for Buick Mine (LimnoTech, 2012) did not identify any significant measures to reduce mine water flows. The Buick Underground Water Management Plan did identify several BMPs to be implemented underground to minimize the concentration of metals in mine water pumped to the surface, but the effect of implementing these measures has not yet been determined. Because mine water is discharged directly to the mine water basin, there is limited opportunity for BMPs at the surface to reduce mine water concentrations of metals. Any BMPs at Buick would be designed to reduce other sources of flow and/or metals to the basin.

There are two other sources of flow and metals to the Buick mine water basin, as discussed in Sections 2 and 3. These are stormwater, treated domestic wastewater, and truck wash water. However, the analyses presented in Sections 2 and 3 of this plan do not indicate that either of these sources is significant enough to affect effluent quality at present. In addition, numerous best management practices and procedures are already employed at Doe Run facilities as part of an overall stormwater management program and are discussed in the Buick Stormwater Pollution Prevention Plan (RMC, 2011). No additional practices to significantly reduce solids and metals loading the Buick mine water basin were identified for this plan.

5.2 WASTE MINIMIZATION

Waste minimization generally refers to the intentional reduction of potentially polluting by-products from industrial process that could affect water quality. At the Buick facility, the major source of metals in the effluent is the naturally occurring minerals in the Buick mine. Therefore, no opportunities for waste minimization were identified for this SWMP.

5.3 WATER REUSE OR RECLAMATION

Water reuse or reclamation can sometimes be used to reduce the total volume of effluent, thereby reducing the loading of materials to receiving waters. At Buick, water from the mine water tank is used in the mill and used for washing trucks, then discharged to the tailings impoundment, as described in Section 2.1.6 of this plan. No other opportunities for water reclamation or reuse were identified for this SWMP.

5.4 WATER TREATMENT

Water treatment is often the last water management measure to be implemented prior to discharge. At Buick, the routing of flow through the mine water basin, tailings impoundment, meander system and clear water basin is intended to provide treatment of mine water by allowing suspended solids to settle from suspension, thereby reducing TSS and total metals prior to discharge. Based on the data presented in Section 4, the mine water basin, tailings impoundment, and meander system are capable of reducing TSS and most total metals. However, even with high rates of solids and metals removal, the resulting total metals concentrations for lead, nickel, and zinc at outfall 002 still have the potential to be higher than the future final effluent limits in the Buick MSOP. Because of this, additional treatment may be required. Doe Run has recently started a series of engineering studies to evaluate mine water treatment, including the following:

- In late 2010 and early 2011, Doe Run commissioned a pilot study of coagulation/flocculation to treat metals in mine water (Barr, 2011). This study concluded that chemical precipitation could potentially reduce metals in mine water to meet future final MSOP limits.
- Also in 2011, Doe Run conducted pilot studies of biotreatment at the Sweetwater, Viburnum 29, and Buick facilities (RMC, 2012). The biotreatment technology tested was a modified version of the system that is currently in place at Doe Run's West Fork facility. The results showed that biotreatment has the potential to achieve low concentrations of target metals in mine water effluent.
- Doe Run has contracted for two pilot studies to further evaluate chemical precipitation for achieving future final MSOP limits. These tests are designed to verify the effectiveness of the technology and provide the basis for confident engineering design and cost estimation.

Upon completion of the pilot tests that are currently underway, Doe Run will evaluate all information developed as a result of the recent studies, determine the most effective and cost-effective treatment technology for mine water, and compare the feasibility of a new mine water treatment plant at Buick to the effectiveness and cost-effectiveness of the alternate discharge practice described in the following section.

5.5 ALTERNATIVE DISCHARGE PRACTICES

Because of the observations presented in Section 4.4 regarding the seasonal improvement in metals reduction rates and the current project to raise the level of the tailings dam, additional study of the advantages associated with extended retention and seasonal management practices may be warranted.

Such study, if undertaken, may consider:

- Effect on mill operations and tailings placement;
- Effect on observed treatment benefit;
- Need for infrastructure required to support the practice;
- Accommodation of extreme precipitation events;
- Optimum months to store water; and,
- Costs.

To the extent that information is developed that would significantly impact the overall water management practices at the facility, such impacts will be documented in the next update of this plan.

5.6 OTHER WATER MANAGEMENT MEASURES

No other significant water management measures are planned at this time, pending the results of the pilot tests previously mentioned.

6. PLAN IMPLEMENTATION

Implementation of the Buick SWMP is detailed in this section. Doe Run intends to implement this plan using an adaptive management process which includes the following elements:

- Evaluation of the potential water management measures described in Section 5, focusing on cost-effectiveness and impact on water quality;
- Identification of water management measures;
- Implementation of identified actions;
- Monitoring of implemented actions (data collection and review);
- Evaluation of results;
- Modification of plan and actions based on monitoring results and evaluations of effectiveness, feasibility and cost-effectiveness.

In addition, Doe Run will conduct a complete review of this plan annually, not only to evaluate information gleaned from monitoring, but to evaluate whether other new information should be considered. The key elements of the Buick SWMP discussed in this section are:

- Water management measure evaluations
- Monitoring
- Recordkeeping
- Training
- Coordination/interface with other plans
- Adaptive management/plan update
- Schedule

These plan elements are discussed in more detail in the following sections.

6.1 WATER MANAGEMENT MEASURE EVALUATIONS

Several water management evaluations are planned to support determination of the most effective and economical way to meet future final MSOP limits at Buick, as discussed in the preceding section. These include the following:

- Completion of two pilot studies to further evaluate chemical precipitation for achieving future final MSOP limits. These tests are designed to verify the effectiveness of the technology and provide the basis for confident engineering design and cost estimation.
- Completion of the evaluation of extended detention in the tailings impoundment to take advantage of observed seasonal increases in metals reductions. This evaluation is ongoing.

- Upon completion of the mine water treatment pilot tests currently underway, Doe Run will evaluate of the cost-effectiveness of a mine water treatment for Buick and timing for completion of treatment construction.

The schedule is presented in Section 6.7.

6.2 MONITORING

Ongoing water quality monitoring may be continued at the Buick facility to improve the understanding of the impacts of management practices on water quality, including sources and fate of metals. The locations identified in Table 6-1 may be sampled.

Table 6-1. Surface Water Sampling Locations for the Buick Mine.

Location	Sample ID Previously Used	Rationale
Tailings impoundment outfall	Buick002	Permit-required monitoring
Mine water entering mine water basin	BU-MW	Continued monitoring of mine water entering mine water basin
Mine water entering tailings impoundment	BU-MWAbTI	Continued monitoring of mine water entering tailings impoundment
Tailings impoundment decant structure	BU-TIDecant	Continued monitoring of mine water leaving tailings impoundment

These samples reflect the sampling baseline that may be continued at the Buick facility to verify the conclusions and observations described in the plan. The facility is currently planning to collect samples as often as monthly at each of these locations for the first 6 months of the first plan year. If the distribution of the data indicates that monthly sampling is unlikely to provide a different understanding of water quality at these locations, the facility may cease monitoring or monitoring frequency at some or all of the locations may be reduced.

If additional data collected indicates a different trend or distribution, future updates to this plan will describe the additional data collected and discuss how those data are used in the evaluation of management practices. In addition to the baseline monitoring described above, supplemental monitoring may be performed to evaluate various water management measures in order to evaluate effectiveness of the measures and to inform the adaptive management process for surface water management at the Buick facility.

6.3 RECORD-KEEPING

Best management practices are inspected at Buick pursuant to the SWPPP and these inspection records will be kept on site.

6.4 TRAINING

Training was identified in the Master Surface Water Management Plan and will be an important part of the plan for Buick. Initial training will be provided to personnel directly involved in the management of water at Buick including, but not necessarily limited to:

- Maintenance personnel
- Environmental technicians

Initial training will be provided within two months of plan approval. In addition to the initial training for these personnel, annual refresher training for appropriate personnel will be conducted in conjunction with SWPPP training. The purpose of the training will be to educate personnel on the need for water management and the key elements of this plan. Initial training will cover the following topics:

- The need for surface water management (including the environmental need);
- Best management practices to be used throughout the facility;
- Specific water management actions being implemented or planned;
- Water management protocols and standard operating procedures, if any;
- Record-keeping;
- Communications and team responsibilities.

The training program will provide a consistent set of guidelines and promote the importance of good water management practices. To the extent possible, the training programs across all SEMO mines will have a consistent structure and uniform protocols and standard operating procedures.

6.5 INTERFACE WITH OTHER PLANS

As part of an overall water management and compliance program, Doe Run has developed and maintains other plans for the Buick facility that include activities closely related to this plan: the Underground Water Management Plan (UWMP, LimnoTech, January 2012) and the Stormwater Pollution Prevention Plan (SWPPP; RMC, April 2011).

6.5.1 Underground Water Management Plan

The Buick UGWMP contains an evaluation of the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce solids and metals loading to surface waters at the facility from underground operations. It provides a summary of mine water flow and monitoring information and a description of activities that contribute to the presence of solids and metals in mine water. The plan provides a description of current practices used to minimize solids and metals in mine water as well as an evaluation of additional practices. The plan also provides recommendations for future activities and monitoring to support the continuing evaluation of current and potential management practices and activities for minimizing the presence of solids and associated metals in mine water pumped to the surface.

Underground water management activities can have a direct impact on water quality pumped to the surface. The following coordination activities will be considered to enhance connectivity between the two planning efforts and to maximize the utility of the information generated by each plan:

- As appropriate, communication of changes in underground water management practices between underground and surface management staff and
- As appropriate, coordination of underground and above ground sampling to support the evaluation of spatial and temporal trends in water quality.

Any significant changes in mine operation or underground water management that could affect surface water management at Buick may be discussed in future versions of the Buick SWMP.

6.5.2 Stormwater Pollution Prevention Plan

The Buick Mine Stormwater Pollution Prevention Plan (SWPPP) identifies industrial activities conducted and significant materials stored at the facility. The plan contains a description of the management practices and procedures used to minimize the exposure of activities and materials to stormwater runoff. The plan also includes a description of training and inspection procedures used to track and document activities, materials, and management practices.

6.6 ADAPTIVE MANAGEMENT/PLAN UPDATE

This plan will be reviewed by the water management team annually for the first two years of implementation and updated as needed. The first plan review and update will occur between April 1 and May 31, 2013. After the first two years, the frequency of review and update will be reassessed. The most current version of the plan will be kept on file at the Buick facility.

6.7 IMPLEMENTATION SCHEDULE

The schedule for the first year of water management plan implementation is presented in Table 6-2. This schedule is based on the best information available as of the date of this plan. Any deviations from this schedule will be communicated in writing to the agencies with an explanation.

Table 6-2. Implementation Schedule for First Year Surface Water Management Plan Activities at Buick.

Action	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	March 2013	April 2013	May 2013	June 2013
Training	Initial training to be provided within 2 months of plan approval											
Plan Review & Update												

Doe Run is evaluating the feasibility of possible treatment options at Buick and other facilities. Doe Run will then move to determinations of final treatment technologies and the sequence of construction for Doe Run facilities, including Buick. Doe Run will provide additional information regarding schedules as appropriate.

This page is blank to facilitate double sided printing.

7. REFERENCES

Barr Engineering Co. *The Doe Run Company – Casteel Mine Pilot Testing Results and Treatment System Design Basis Report*. April 2011. (Barr, 2011).

Drew, J. D., and S. Chen, 1997. *Hydrologic Extremes in Missouri: Flood and Drought*. Missouri State Water Plan Series Volume V. Missouri Department of Natural Resources, 141 pp.

Huff, F. A., and J. R. Angel, 1992. *Rainfall Frequency Atlas of the Midwest*. Illinois State Water Survey Bulletin 71, 141 pp.

LimnoTech. *Master Surface Water Management Plan*. (LimnoTech, 2011a).

LimnoTech. *Surface Water Sampling and Analysis Plan (Revision 1)*. January 6, 2011. (LimnoTech, 2011b).

LimnoTech. *Surface Water Sampling and Analysis Plan Report*. September 30, 2011. (LimnoTech, 2011c).

LimnoTech. *Underground Water Management Plan for Buick Mine*. (LimnoTech, 2012).

Resource Environmental Management Consultants, Inc. *Stormwater Pollution Prevention Plan for Buick Mine/Mill*. (RMC, 2011).

Resource Environmental Management Consultants, Inc. *Biotreatment Pilot Test Final Results Report*. (RMC, 2012).

Rockaway, T.D., P.A Coomes, J. Rivard, B. Kornstein. 2011. Residential Water Use Trends in North America. *Jour. AWWA*, 103:2, pp. 76-89.

U.S. Geological Survey. "History of Mining in the Southeast Missouri Lead District and Description of Mine Processes, Regulatory Controls, Environmental Effects, and Mine Facilities in the Viburnum Trend Subdistrict" (Chapter 1 of *Hydrologic Investigations Concerning Lead Mining Issues in Southeastern Missouri*, Scientific Investigations Report 2008–5140). 2008. (USGS, 2008).

USEPA, 2009. *Urban Stormwater BMP Performance Monitoring Manual*. Chapter 7, pp. 7-10 and 7-23.

This page is blank to facilitate double sided printing.

EXHIBIT Z

HERCULANEUM SMELTER SURFACE WATER MANAGEMENT PLAN

January 10, 2012,
Revised October 29, 2012

PREPARED FOR:

The Doe Run Resources Corporation
d/b/a: The Doe Run Company
1801 Park 270 Drive
Suite 300
St. Louis, MO 63146

Herculaneum Smelting Division
881 Main Street
Herculaneum, MO 63048

RESOURCE & ENVIRONMENTAL MANAGEMENT CONSULTANTS, INC.
MIDVALE, UTAH PHONE: (801) 255-2626 FAX: (801) 255-3266

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

This Site-Specific Surface Water Management Plan (SWMP) has been prepared for The Doe Run Resources Corporation, d/b/a/ The Doe Run Company (Doe Run), Herculaneum Smelting Division, Herculaneum Smelter (Herculaneum Smelter) Facility.

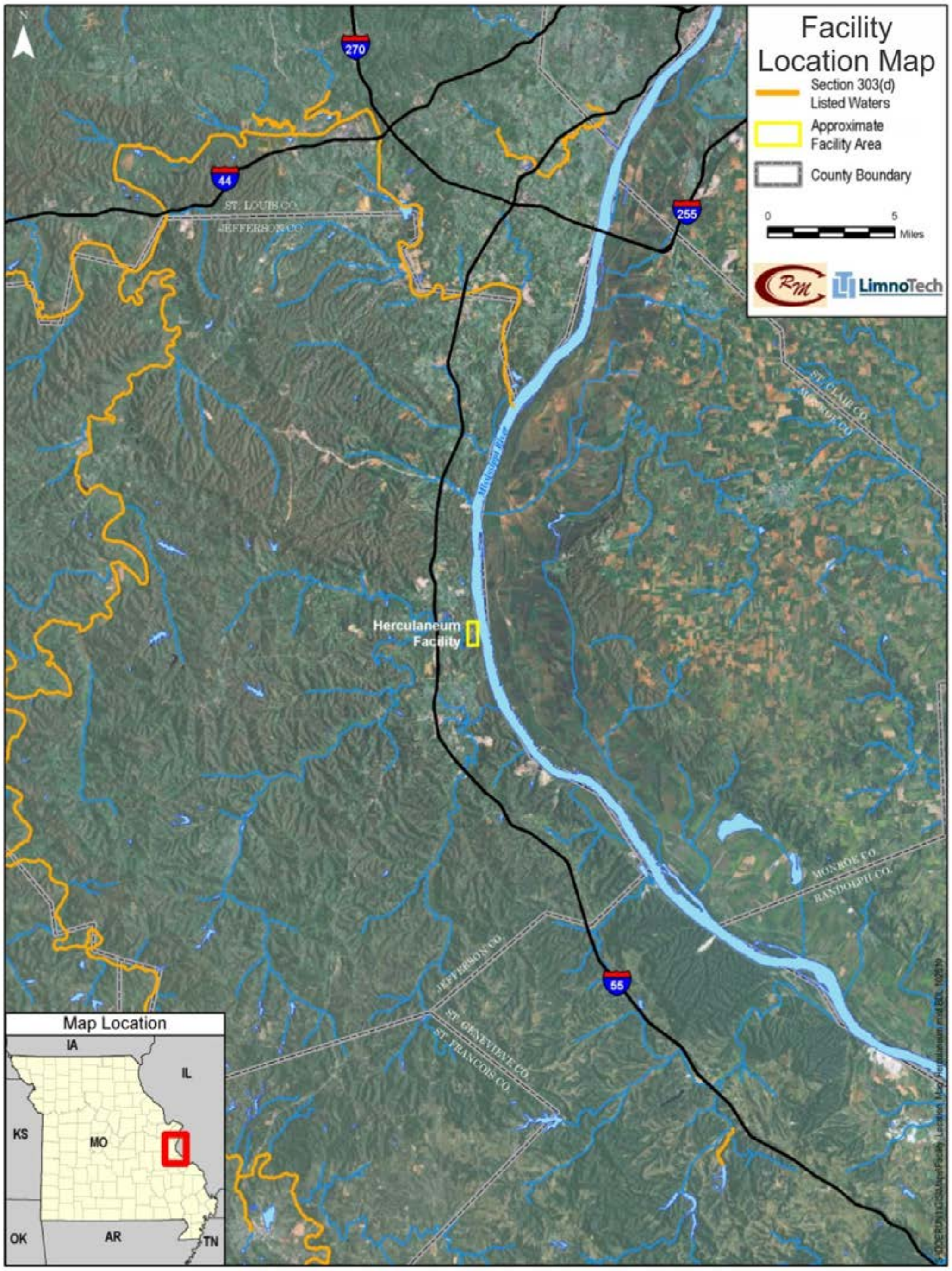
This Herculaneum Smelter SWMP in accordance with the Master Surface Water Management Plan previously prepared by LimnoTech (Master SWMP, LimnoTech). This SWMP evaluates the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading in facility surface water and maximizing the capabilities of the waste water treatment plant (WWTP). The primary objective of this SWMP is attaining compliance with final effluent limitations contained in the Herculaneum Smelter Missouri State Operating Permit (MSOP).

1.1 FACILITY BACKGROUND

Doe Run's Herculaneum Smelting Division in Herculaneum, Missouri operates a primary lead smelter that produces high-purity lead from lead concentrates. This lead product is used in everyday applications such as computer screens, car batteries, protective equipment and other specialties.

The Herculaneum Smelter is located approximately 25 miles south of St. Louis, Missouri. The Herculaneum Smelter employs approximately 282 professional, technical, skilled and administrative personnel. A Site Location Map is presented in Figure 1-1. A Smelter Facility Site Plan is presented in Figure 1-2 (Sheets 1 and 2).

Figure 1-1: Location for Doe Run Herculaneum Smelter Facility




HS-0-02
HS-0-03
HS-0-04
HS-0-05
HS-0-06
HS-0-07
HS-0-08
SOUTH TANK
NORTH TANK
SUMP
THICKENER
STEM WALL
SUMP
HS-0-09
PROPOSED WATER CATCHMENT
#9 TANK (MILLION GALLON)
SLAG REMOVED TO SSA
HS-0-10/11
PUMP
OUTFALL 003
OVERLAND FLOW BOUNDARY
OUTFALL 005 (ELIMINATED)
WATER CATCHMENT
OUTFALL 001
LEGEND
SURFACE FLOW DIRECTION (NOTE: GROUPED BY COLOR)
CURRENT FEATURE
PLANNED FEATURE
SAMPLE LOCATION
SCALE
0 125 250
FEET
DOE RUN COMPANY
FIGURE 1-2 SHEET 1
HERCULANEUM SWMP
SITE PLAN
RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626
MARCH 2012
herky swmp site plan.dwg


LEGEND
SURFACE FLOW DIRECTION
(NOTE: GROUPED BY COLOR)
CURRENT FEATURE
PLANNED FEATURE
SAMPLE LOCATION
SLAG
STORAGE
AREA
BERM
HS-0-01
HS-0-02
OUTFALL 004
SCALE
0
125
250
FEET
N
DOE RUN COMPANY
FIGURE 1-2 SHEET 2
HERCULANEUM SWMP
SITE PLAN
RESOURCE MANAGEMENT CONSULTANTS
8138 SOUTH STATE ST.
SUITE 2A
MIDVALE, UT 84047
801-255-2626
MARCH 2012
herky swmp site plan.dwg

1.2 SWMP OBJECTIVES

As stated above, the main objective of this SWMP is to evaluate the technical and economic feasibility, practicality, and effectiveness of procedures and methodologies to reduce metals loading in facility surface water and maximize the capabilities of the in order to attain compliance with final effluent limitations in the Herculaneum Smelter MSOP.

In furtherance on this objective, the Herculaneum Smelter's approach to surface water management includes the following:

- Identification of the specific components of the surface water system at each facility;
- Identification of the site-specific sources of increased metals concentrations in the surface water system;
- Identification of the management actions and controls which may aid in reducing metals loading to surface waters at the facility;
- Providing a decision-making framework for Doe Run personnel to make effective surface water management decisions;
- Evaluation of program effectiveness through monitoring; and
- Training personnel for effective plan implementation.

Water sources at the Herculaneum Smelter covered under this SWMP include:

- Process water, including non-contact cooling water;
- Truck wash water;
- Facility and roadway washdown water;
- Slag leachate water collection; and
- Storm water runoff.

The current NPDES Permit (MO-0000281) was issued on February 25, 2011, revised on March, 18, 2011, and revised again on March 20, 2012. The permit expires on February 24, 2016. Interim permit limits are in effect from the date of issuance until February 24, 2014. Final permit limits are effective from February 25, 2014 through February 24, 2016. Alternative limits and compliance schedules to those provided in the MSOP set forth in Appendix B of the Doe Run Multi-Media Consent Decree (Case 4:10- cv-01895, entered December 21, 2011). Alternative limits under the Consent Decree are the same as the interim limits for metals. Pursuant to the Consent Decree the alternative limits are in effect for three (3) years from the date of approval of the Site-Specific SWMP, but not to exceed five (5) years from the Effective Date of the Consent Decree (December 21, 2011).

As described in more detail below, the Herculaneum Smelter facility is currently discharging effluent that is substantially in compliance with final MSOP limits. Permitted Outfalls are described below:

Outfall 001

Outfall 001 consists of discharges from the Facility WWTP. Outfall 001 discharges to the Mississippi River. This is the primary discharge point for the Facility. All process and storm water is treated by the WWTP prior to discharge. Current data for Outfall 001 permitted metals is presented in Section 1.3.

Outfall 003

Outfall 003 discharges non-contact cooling water to the Mississippi River. The water sources for this non-contact cooling water are the Ranney Well and Herculaneum City water. Non-contact cooling water includes discharges from the Strip Mill Cooling, Blast Furnace Cooling Tower and Acid Plant Cooling Tower.

Outfall 004

Outfall 004 is a stormwater outfall near the Slag Storage Area (SSA). Joachim Creek, a tributary to the Mississippi River, is the receiving stream. Stormwater discharge from the wetland area adjacent to the SSA flows through Outfall 004. There is no industrial activity occurring in this wetland area. Typical flows of less than 10 gpm have been observed in this area. Following closure of the SSA and appropriate regulatory approvals, stormwater discharge from the SSA will flow to Outfall 004 and Joachim Creek.

MSOP limits for Outfall 001 are presented below:

Table 1-1: MSOP Effluent Limits – Outfall 001[1]

Metal	Daily Maximum Interim Limit	Daily Maximum Final Limit
Ag	**	**
As	3.98 lbs/day	3.98 lbs/day
Cd	1.964 lbs/day	1.22 lbs/day
Cu	3.67 lbs/day	2.77 lbs/day
Pb	3.03 lbs/day	3.03 lbs/day
Sb	*	*
Tl	*	*
Zn	11.04 lbs/day	11.04 lbs/day

Metal	Monthly Average Interim Limit	Monthly Average Final Limit
Ag	**	**
As	1.69 lbs/day	1.69 lbs/day
Cd	0.785 lbs/day	0.61 lbs/day
Cu	1.6 lbs/day	1.40 lbs/day
Pb	1.26 lbs/day	1.26 lbs/day
Sb	*	*
Tl	*	*
Zn	3.73 lbs/day	3.73 lbs/day

Notes:

1. Permit MO-000028, dated March 20, 2012 (revised).
2. * - Monitoring only.
3. ** - Effluent limits removed in March 20, 2012 MSOP revision.

1.3 CURRENT DISCHARGE DATA AND COMPARISON WITH INTERIM AND FINAL MSOP LIMITS

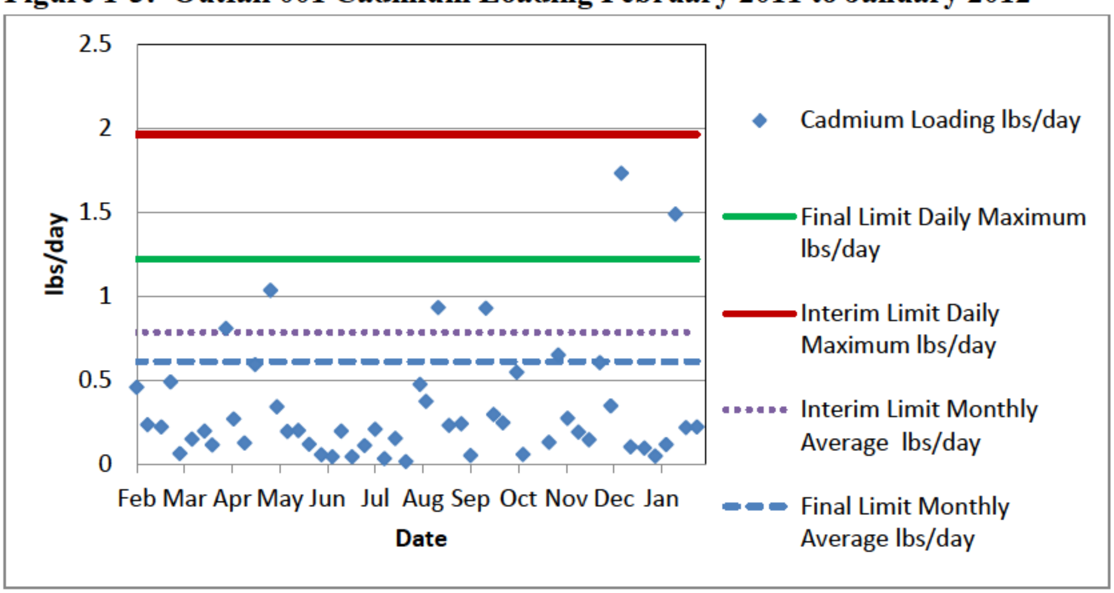
This Section compares Outfall 001 discharge data for metals to the interim and final Daily Maximum and Monthly Average MSOP effluent limits presented in Table 1-1 for the time period of February 2011 to January 2012.

Final effluent limits for Outfall 003 include monitoring only requirements for flow, temperature, arsenic, cadmium, copper, lead and zinc. Oil and Grease limits are 15 mg/l Daily Maximum and 10 mg/l Monthly Average. Monitoring requirements for pH are between 6.5 s.u. and 9.0 s.u. A review of DMR data, for Outfall 003, from February 2011 to January 2012 reveals there were no exceedances of effluent limits for this Outfall. Final effluent limits for Outfall 004 are monitoring only. As such this Section focuses on Outfall 001.

1.3.1 Cadmium

Based on a review of Daily Maximum discharge data for fifty-two cadmium samples collected from February 2011 to January 2012, there were no exceedances of the interim limits for cadmium. There were two exceedances of future final MSOP Daily Maximum permit limits and seven exceedances of the future final MSOP Monthly Average permit limits for cadmium during this time period. Outfall 001 discharge data for cadmium during the time period February 2011 to January 2012 is presented graphically in the following figure:

Figure 1-3: Outfall 001 Cadmium Loading February 2011 to January 2012

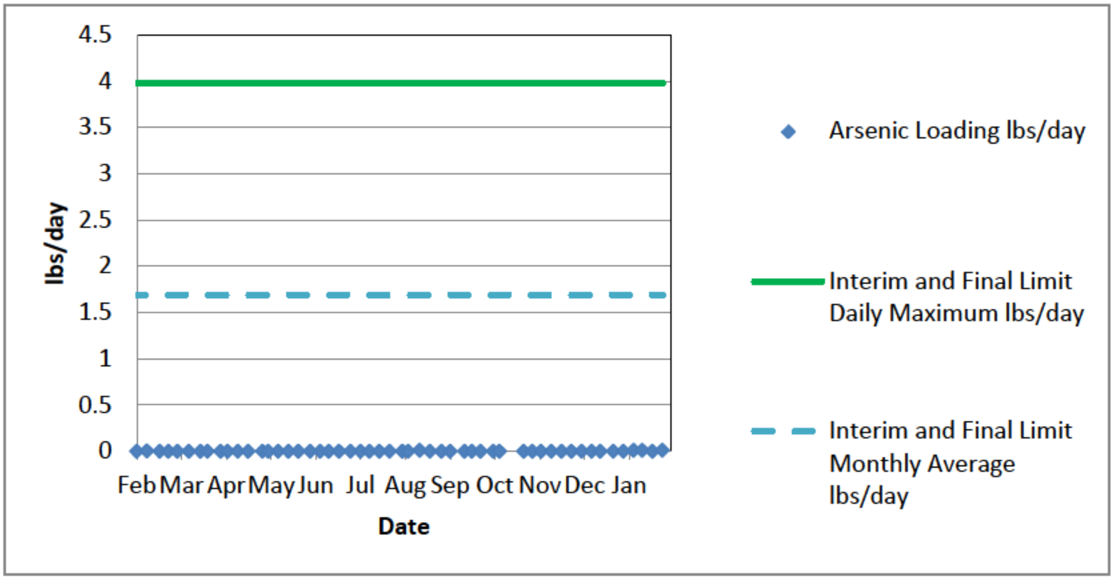


Meeting permit limits for cadmium will be the primary compliance issue addressed in this plan. Where possible, specific procedures to reduce cadmium loading may be implemented when technically feasible and cost effective. It is expected that cadmium loading will be reduced by an overall facility-wide reduction in metals loading, source reduction, and pollution prevention opportunities as outlined in Section 3.4.

1.3.2 Arsenic

Based on a review of Daily Maximum discharge data for fifty-two arsenic samples collected from February 2011 to January 2012, there were no exceedances of the interim limits. Outfall 001 discharge data for arsenic during the time period February 2011 to January 2012 is presented graphically in the following figure:

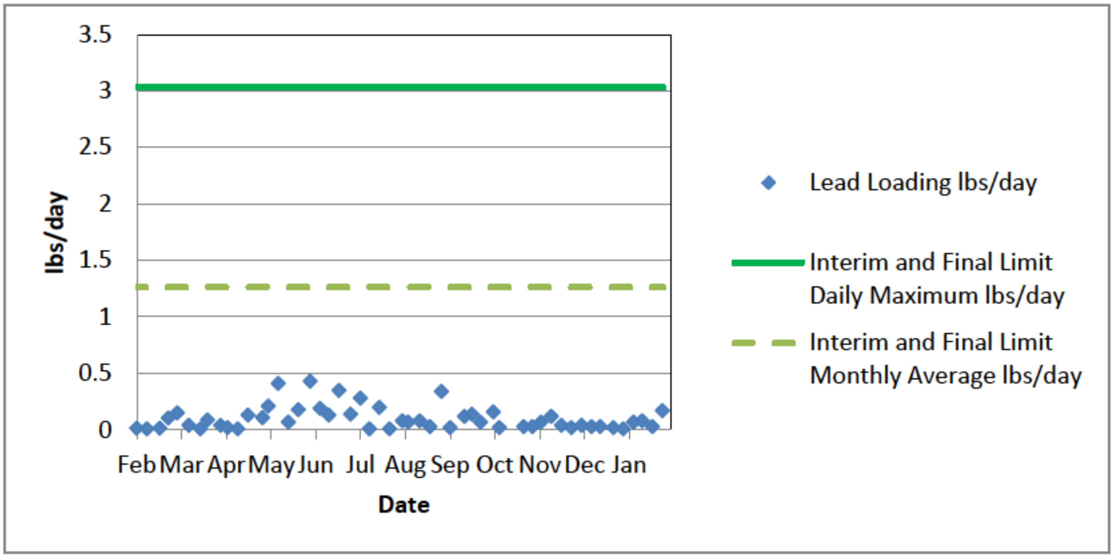
Figure 1-4: Outfall 001 Arsenic Loading February 2011 to January 2012



1.3.3 Lead

The interim and final MSOP limits for lead are the same. Based on a review of Daily Maximum discharge data for fifty-two lead samples collected from February 2011 to January 2012, there were no exceedances of the permit limits. Outfall 001 discharge data for lead during the time period February 2011 to January 2012 is presented graphically in the following figure:

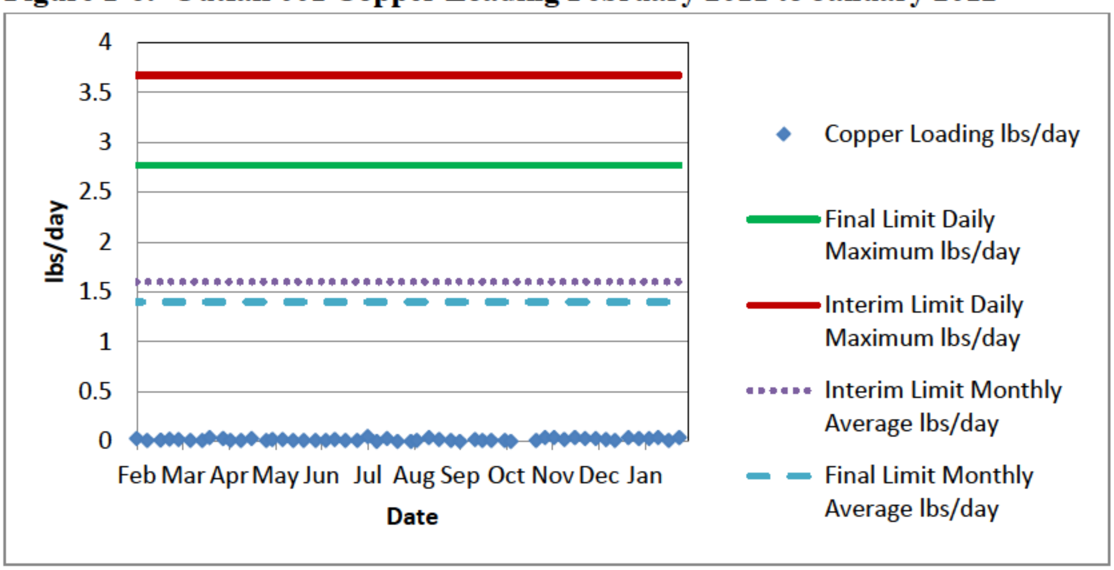
Figure 1-5: Outfall 001 Lead Loading February 2011 to January 2012



1.3.4 Copper

Based on a review of Daily Maximum discharge data for fifty-two copper samples collected from February 2011 to January 2012, there were no exceedances of the interim or final limits. Outfall 001 discharge data for copper during the time period February 2011 to January 2012 is presented graphically in the following figure:

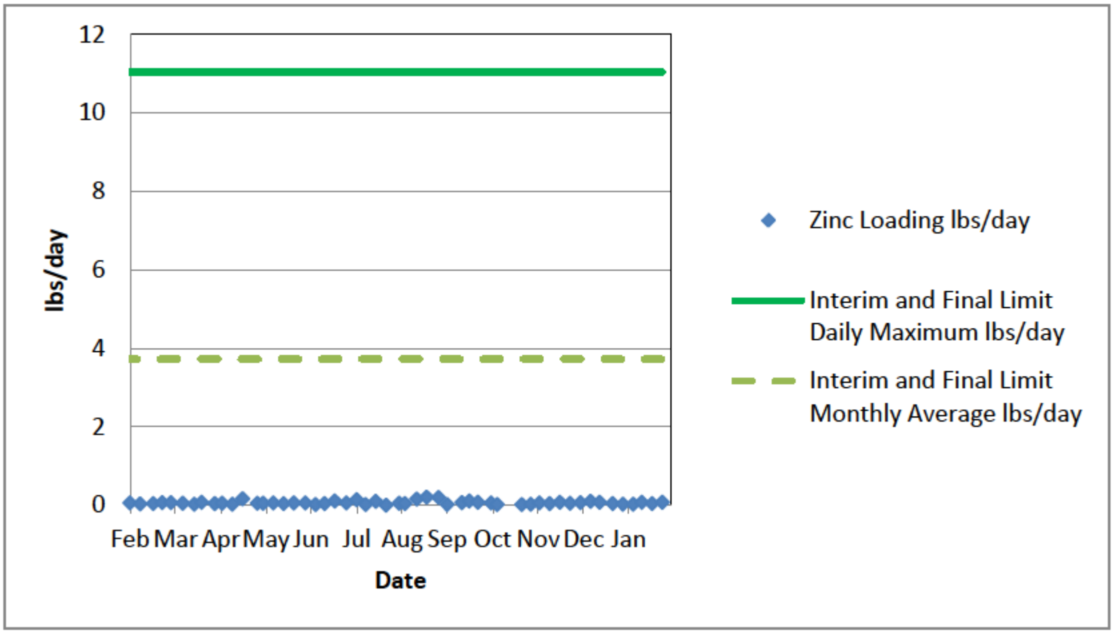
Figure 1-6: Outfall 001 Copper Loading February 2011 to January 2012



1.3.5 Zinc

The interim and final MSOP limits for zinc are the same. Based on a review of Daily Maximum discharge data for fifty-two zinc samples collected from February 2011 to January 2012, there were no exceedances of the permit limits. Outfall 001 discharge data for zinc during the time period February 2011 to January 2012 is presented graphically in the following figure:

Figure 1-7: Outfall 001 Zinc Loading February 2011 to January 2012



2. PROJECT MANAGEMENT

This section describes the project management for the Herculaneum Smelter SWMP, including the plan distribution list, project organization, water management hierarchy for decision-making, and management focus on pollution prevention.

2.1 SWMP TEAM

Currently, the SWMP team consists of managers, engineers and technical specialists. This SWMP and subsequent revisions will be distributed to the following team members:

Rusty Keller
Environmental Manager
Herculaneum and Glover Facilities
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Chris DeCioccio
Environmental Engineer
Herculaneum and Glover Facilities
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Patrick Murphy
Environmental Specialist
Herculaneum and Glover Facilities
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Kevin Ferguson
Environmental Technician
Herculaneum and Glover Facilities
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Bruce Chamberlain
Plant Operations Manager
Herculaneum Facility
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Francis Razzano
Assistant Plant Operations Manager
Herculaneum Facility
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Stan Lafollette
Chief Maintenance Engineer
Herculaneum Facility
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

John Heilig
Operations Prep Supervisor
Herculaneum Facility
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

Dave Bailey
Engineering & Construction Manager
Herculaneum Facility
The Doe Run Company
881 Main Street
Herculaneum, MO 63048

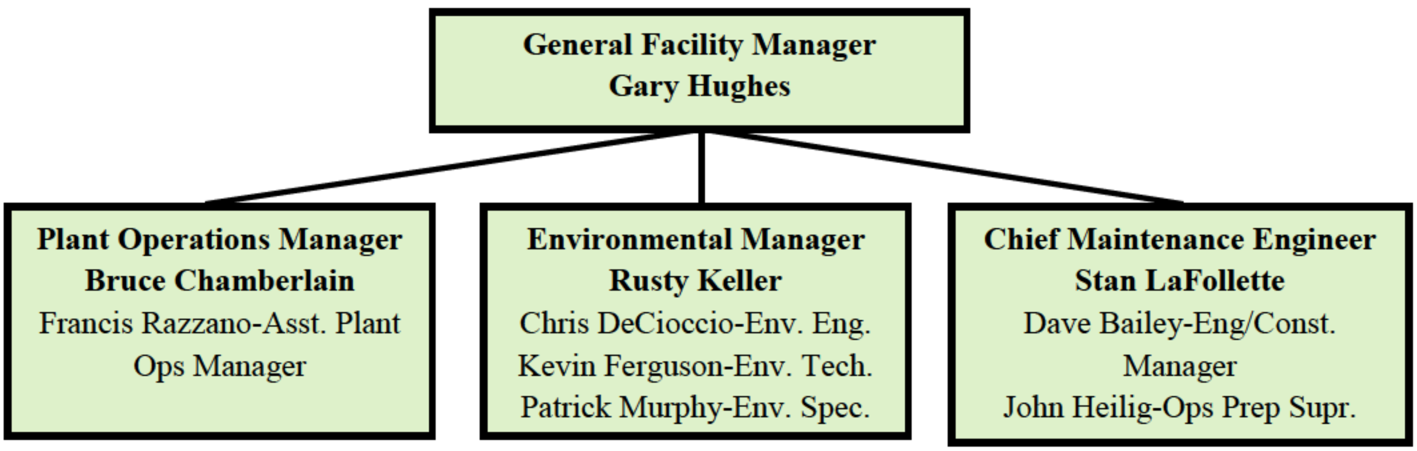
2.2 PROJECT ORGANIZATION

The Herculaneum Surface Water Management Plan team consists of Doe Run personnel. The purpose of this team is to combine requirements from management, operations and environmental departments into a comprehensive team. A team approach ensures that both management and technical personnel are involved in all steps of the surface water management process.

Doe Run's Environmental Project Manager at the Herculaneum Smelter is Rusty Keller, who is responsible for this SWMP project management and communication with corporate managers and facility personnel. Chris DeCioccio, Environmental Engineer, will be responsible for implementation of the SWMP with assistance from Patrick Murphy and Kevin Ferguson. Bruce Chamberlain is the Plant Operations Manager. He is supported by Francis Razzano. Stan Lafollette is the Chief Maintenance Engineer. He is supported by John Heilig and Dave Bailey.

A chain-of-command for Herculaneum is outlined in the organizational chart presented below in Figure 2-1:

Figure 2-1: Chain of Command Organizational Chart

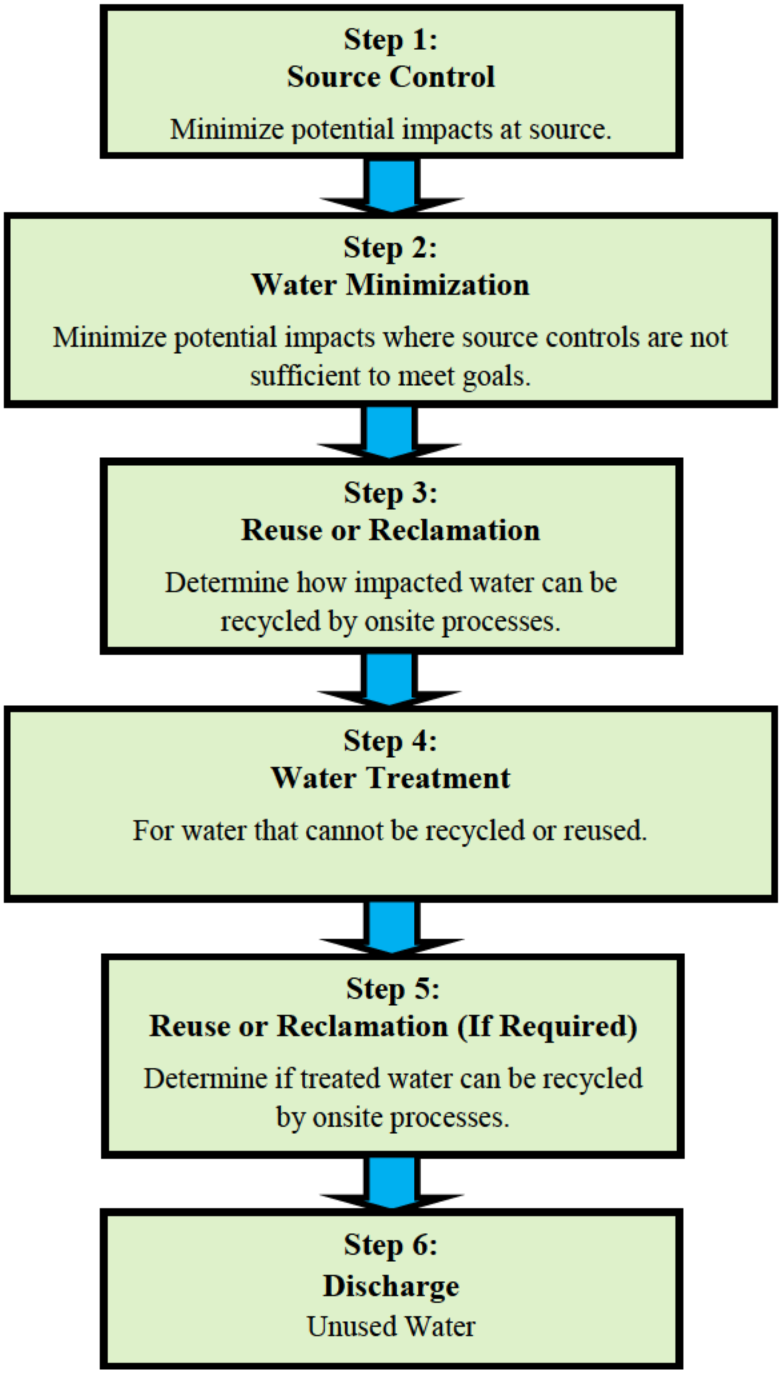


2.3 WATER MANAGEMENT HIERARCHY FOR DECISION-MAKING

A step-wise water management hierarchy was presented in the Master SWMP to set a clear priority-based process for considering and implementing management decisions. The hierarchy sets priorities for the management of water at Doe Run facilities. Facility managers, contractors, and employees will consider this hierarchy in their decision making processes.

The water management hierarchy, shown below in Figure 2-2, identifies as the top priority source control or pollution prevention through the implementation of Best Management Practices (BMPs). In the context of site-specific BMPs, this means that priority will be given to technologies and/or practices that reduce the loading of metals in discharges to waters of the State. If source control measures are not sufficient to meet management goals, water minimization and reuse or reclamation measures are second and third priorities. Once the top three priorities have been optimized, and if further measures are both necessary and economically feasible, water treatment options beyond those currently employed at the facility will be considered. Reuse or reclamation following treatment, when practical and economically feasible, will be considered as a priority over discharge to waters of the State.

Figure 2-2: Step-Wise Hierarchy of Water Management Priorities



3. SITE-SPECIFIC SWMP COMPONENTS

The major components of the Herculaneum Smelter SWMP are described in this section.

3.1 WATER INVENTORY

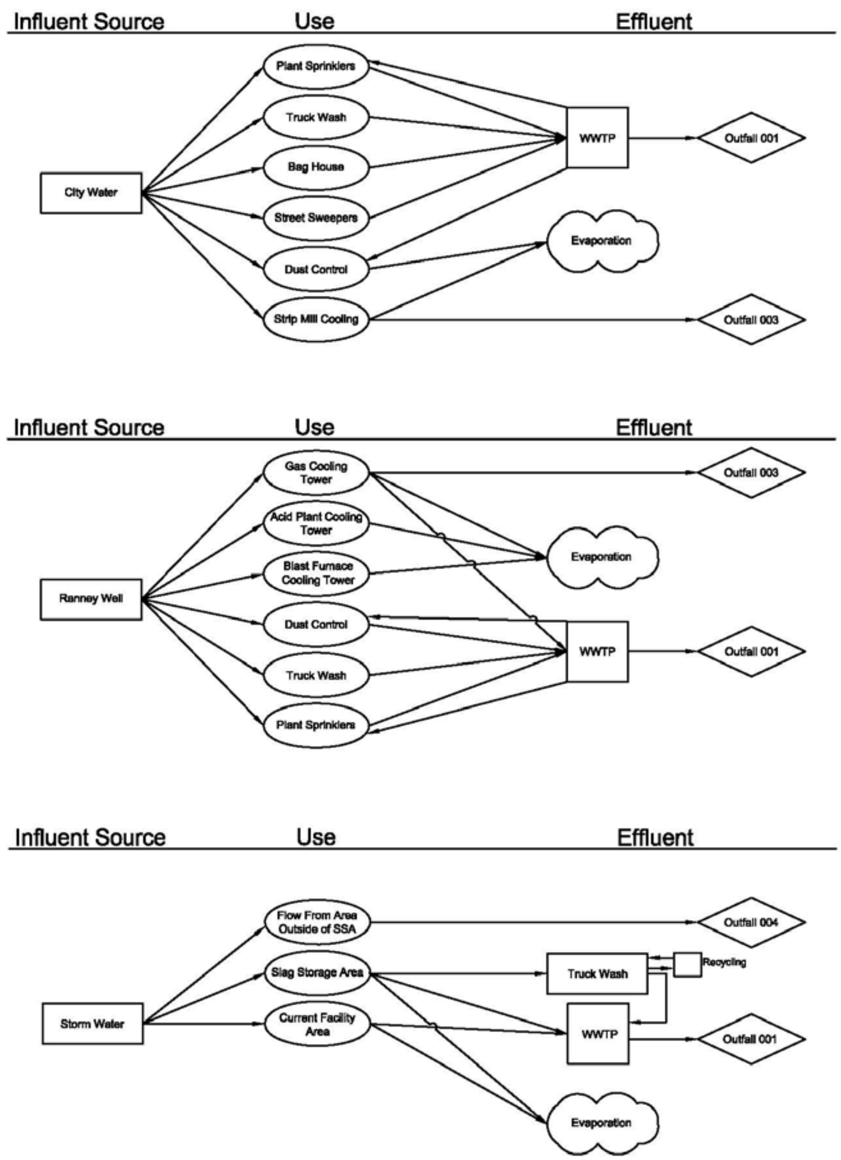
Understanding the components of surface water flow at the Herculaneum Smelter and their relative contributions to the overall water balance is important to understanding how metals might enter and be transported through the facility and eventually be discharged to waters of the State.

The major components of surface water flow through the Herculaneum Smelter facility include:

- Process water, including non-contact cooling water;
- Truck wash water;
- Facility and roadway washdown water;
- Stormwater runoff;
- Slag leachate collection; and
- Evaporation.

A conceptual model of specific surface flow pathways at the facility is depicted in Figure 3-1. The flow pathways are subdivided based on the source of influent water. Elements are duplicated if they utilize multiple sources. This method was chosen to portray generalized flow paths for each source of water at the facility.

Figure 3-1: Herculaneum Smelter Conceptual Flow Schematic



A detailed Water Balance Report was prepared by Doe Run for the Herculaneum Smelter facility in 2008. The Water Balance Report is attached to this SWMP (Appendix A) and is incorporated into this SWMP by reference (Water Balance Report, Doe Run Company, 2008). The Water Balance Report is the most detailed assessment of water use at the facility to date and was used as a baseline characterization of plant water use. Changes in current operations that have occurred since the completion of the Water Balance Report (Doe Run Company, 2008) and that have resulted in decreased loading to the include:

- Reduced water usage at the Number 5 baghouse;
- Use of slag storage area stormwater runoff as Truck Wash water; and
- Recycling of Truck Wash process water.

Outflows from the facility are assumed to be equal to inflows minus evaporation. The majority of the facility consists of impervious surfaces and all process water and stormwater runoff is captured via a drainage system that routes runoff to steel holding tanks prior to treatment at the facility's waste water treatment plant (WWTP). Thus, there is minimal potential for infiltration and loss of process water and stormwater to groundwater. Potential stormwater storage capacity and outflows are discussed further in Section 3.1.1.

Groundwater data from monitoring wells near the SSA, during 1987 to1989, indicate that there was one exceedance of the arsenic Maximum Contaminant Levels (MCL) in eighteen samples and four exceedances of the lead MCL in seventy-two samples. Three samples contained lead concentrations equivalent to the MCL of 0.015 ppm. Data from 2000 to 2002 contained three exceedances of drinking water MCLs for lead and one for arsenic. The last round of data collected in September 2011 did not contain any exceedances of drinking water MCLs. The wells are shallow groundwater monitoring wells completed near ground surface and are not drinking water wells.

In anticipation of cessation of pyrometallurgical operations (cessation of operation of the sinter machine, blast furnaces and acid plant) and potential repurposing of the facility, Doe Run has initiated two studies focused on potential future loading demands on the WWTP. The first study, a Water Characterization Study (Water Study, RMC 2011b), analyzes current data and provides loading estimates for the existing operations, the potential construction and operation of hydrometallurgical processing (including decommissioning the smelter) and other potential future operations at the facility (after smelter shut-down and decommissioning).

The second study will be a phased study that will first collect and evaluate further data recommended by RMC to evaluate future potential loading to the WWTP. This phase will include, but may not be limited to, collection of additional flow and chemistry at key process steps, updating the flow data in the 2008 Water Balance Report, evaluating process time in the WWTP and investigating cadmium loading. The second phase of this study will be to evaluate future treatment options, if needed, for the transition and future operations at the facility.

Both studies are discussed again in Section 3.4, and the timeline for completion of related reports in conjunction with the studies is presented in Section 4.

3.1.1 Stormwater Storage and Treatment Capacity

This Section evaluates reasonably anticipated storm events at the Herculaneum facility, and the facility's ability to contain and treat such storm events. The calculations assume that the facility is operating at the following steady-state conditions (e.g. constant) which occur regularly:

- The average daily discharge from Outfall 001 is 300 gpm;
- The North and South Tanks are operating at pumped down, steady state levels; and
- The storm surge tank is empty.

Doe Run selected a one-year, 24-hour storm producing 2.8 inches of rainfall as the "reasonably anticipated" rainfall (Rainfall Frequency Atlas of the Midwest, Huff and James, 1992). This storm event would have a 99% probability of occurring annually. The facility stormwater and wastewater treatment systems are adequate to fully contain and treat the 2.8 inch rainfall. Site stormwater capacity was examined based on the following data:

- One-year 24-hour rainfall event of 2.8 inches (Huff and James, 1992); and
- Potential stormwater runoff volumes determined according to United States Department of Agriculture, Natural Resources Conservation Service (NRCS) methodologies.

Potential stormwater runoff was calculated using facility rainfall intensity and curve number values presented in "Urban Hydrology for Small Watersheds, TR-55, United States Department of Agriculture, Natural Resources Conservation Service" (TR-55, NRCS, 1986).

The facility was subdivided into two areas for runoff calculations:

1) Slag Storage Area (SSA); and
2) Smelter facility area.

Slag Storage Area

The SSA was assigned a conservative Curve Number of 40, which is the lowest value presented in TR-55 (NRCS, 1986). The following calculation presented in TR-55 (NRCS, 1986), based on porosity and potential maximum retention, estimated that the actual Curve Number is one order of magnitude lower than 40:

1. S = (1000/CN) -10

Where:
CN = Curve Number
S = Potential Maximum Retention (inches)

If S is calculated as the available voids in the slag, the CN can be estimated by rearranging the equation to:

2. CN = 1000/(S+10)

Based on a slag thickness of 56 feet with a porosity of 30%, the maximum retention would equal 56 feet x 0.30 or 16.8 feet (202 inches). Porosity of the slag was determined from grain-size analysis reported in the Slag Storage Area Removal Action Work Plan (RAWP, Barr, 2007). The average grain size of the slag is equivalent to a medium grained sand that has a porosity of 30% (see, Table 3.2 of http://web.ead.anl.gov/resrad/datacoll/porosity.htm (Argonne National Laboratories, United States Department of Energy).

Rearranging this equation the CN, based on available pore space would be estimated as follows:

CN = 1000/(202 + 10) = 4.7

For the purpose of this analysis a conservative CN of 40 was used.

The SSA stormwater collection system contains redundant pumps each rated for 75 gpm. Only one pump is running at any time. The second redundant pump is used only as a backup if the first pump is not working. Therefore, the capacity of the system is based on the use of one pump. Water volume pumped from the SSA, during the reasonably anticipated storm event will contribute approximately 108,000 gpd of collected stormwater reporting to the truck wash and eventually to the WWTP. As described in Section 3.4.1.2, prior to reporting to the WWTP, SSA water is used in the facility truck wash where it undergoes at least one recycle circuit. Storage capacities presented in Table 3-1 and compliance data described in Section 1.3 indicate that the facility can store and effectively treat the 108,000 gpd contributed from the SSA pumping system. During normal operation the SSA pumps are either off or individually operating at 46-57 gpm with a mean of 52 gpm (see SSASWMP RMC, 2011a). Therefore, utilizing the 108,000 gpd is a conservative value because during normal steady-state operations the volume of water from the SSA would be approximately 74,880 gpd at a flow rate of 52 gpm.

Water in excess of 108,000 gpd will be contained in the SSA which has a storage capacity (controlled by the SSA berm) of approximately 40,000,000 gallons based on an average thickness of 56 feet and typical slag grain sizes of medium sand presented in the RAWP (Barr, 2007). The SSA berm was completed in November 2010 with the exception of a small area (approximately 1% of total containment structure area) that required additional time to achieve final compaction (RMC, 2011a).

Smelter Facility Area

The smelter facility was assigned a Curve Number of 90 to represent an average composite value for the area. The Curve Number of 90 is within the typical range for urban commercial and business districts (NRCS, 1986).

Runoff volumes for the one-year 24-hour rainfall event of 2.8 inches were determined as follows:

Table 3-1: One-Year 24-Hour Rainfall Stormwater Runoff Volumes

Acreage Source	1yr/24hr Rainfall in	Rainfall ft	Area Ac	Area ft^2	CN	Direct Runoff in	Direct Runoff ft	Stormwater Runoff ft^3	Stormwater Runoff gal
Plant	2.8	0.233	40.1	1,746,756	90	1.8	0.150	262,013	1,959,996
SSA	2.8	0.233	36	1,568,160	40	0**	0.000	-	108,000*
Total			**76.1**					**262,013**	**2,067,996**

Notes:
* The SSA contains a pumping system with two redundant pumps rated at 75 gpm. The 108,000 gpm value is the maximum capacity for one pump. The second redundant pump is used only as a backup if the first pump is not working. Therefore, the capacity of the system is based on the use of one pump. This water would contribute to facility runoff totals in extreme rainfall events.
** The direct runoff of 0-inches is due to slag porosity and storage capacity of the SSA.

Based on Table 3-1, the overall stormwater runoff volume for the one-year 24-hour rainfall event is 2,067,996 gallons (assuming that the SSA is contributing 108,000 gallons, although this is unlikely based on normal operating practices as described above).

Facility stormwater capture and storage was determined based on the following capacities:

Table 3-2: Facility Stormwater Storage Capacity

Element	Capacity (gallons)	Notes
#9 Stormwater tank	1,000,000	Tank converted for storage.
North Tank storm surge capacity	139,340	Based on using 3' of the 4' Stem wall (as per Herculaneum engineering).
South Tank storm surge capacity	107,921	Based on using 3' of the 4' Stem wall (as per Herculaneum engineering).
South Tank additional drawdown capacity	323,764	Based on use of pontoon pump that can draw 9' below the stem wall down to within 5' of tank bottom. The total depth below the stem wall is 14'.
Lime pit and truck bed wash sumps	30,000	1-foot of headroom for surge.
WWTP discharge to Outfall 001 (500 GPM to Outfall).	288,000	All WWTP discharges flow to Outfall 001. This includes 200 gpm of WWTP discharge to Outfall 001 that is routed to the North Tank for facility use.
Railroad track area (2' depth)	643,130	Area to the west of railroad tracks. 42,987 square foot area with a depth of 2'.
Total Stormwater Storage Capacity	**2,532,155**	**Total of elements listed above.**
Daily process water throughput	432,000	Based on 300 gpm steady state. This is process water throughput that is always present.
Total Storage Capacity	**2,100,155**	**Stormwater-process throughput.**

*-The daily process throughput represents the average daily discharge from Outfall 001 as reported on Discharge Monitoring Reports from February 2011 to January 2012.

The calculations in Table 3-2 assume that:

- The North Tank is operating at full capacity;
- To maximize storm surge capacity, the South Tank is pumped down to within 5 feet of bottom;

- The 200 gpm of WWTP treated flow that is typically re-routed to the North Tank is discharged to Outfall 001. This adds an additional 200 gpm or 288,000 gallons per day of storm surge capacity; and
- The area contained between the North and South tanks and the railroad tracks is 42,987 square feet. This area can contain a 2-foot depth of storm water and drains to the Slag Cooling sump which can be pumped back to the South Tanks.

The total facility stormwater capacity of 2,532,155 gallons as presented in Table 3-2 is sufficient to contain the 2,067,996-gallon stormwater runoff from the one-year, 24-hour storm event (or a five-year, three-hour rainfall event). Subtracting the average daily WWTP throughput from the total stormwater capacity yields a volume of 2,100,155 gallons. This volume is also sufficient to store the 2,067,996-gallons of stormwater runoff of the one-year, 24-hour storm event (or a five-year, three-hour storm event).

The treatment capacity of the WWTP during large rainfall events was reviewed for the five largest storm events during the period February 2011 to January 2012. The site-specific storm event data was downloaded from the Doe Run meteorological database for the facility. As presented in Table 3-3, the WWTP was able to maintain operational capacity during these storm events. As demonstrated in Section 1.3, the facility was in compliance with current discharge limits during this time period.

Table 3-3: Correlation of WWTP Flow and Five largest Rainfall Events February 2011 to January 2012

Date	Rainfall (in)	WWTP Outflow (mgd)	WWTP Outflow (gpm)
4/22/2011	2.7	0.651	452.1
7/7/2011	1.85	0.472	327.8
9/14/2011	1.68	0.714	495.8
4/27/2011	1.56	0.608	422.2
6/19/2011	1.45	0.304	211.1

The April 22, 2011 rain event resulted in an overflow of the North and South tanks. This occurred prior to the construction of the stem wall and one-million gallon tank. The water was contained in the area between the North and South tanks and the railroad tracks. All water was contained onsite. Since then construction of the stem wall and addition of the one million gallon storm surge tank (as described in 3.4.1.3 and 3.4.1.4) increased the stormwater storage capacity sufficient to contain the 2.8 inch rainfall event.

Stormwater Capacity and Treatment Summary

- Based on the data presented in this Section, the Herculaneum facility has sufficient capacity to store, contain and treat a 2.8-inch storm event. This is equivalent to approximately a one-year, 24-hour storm event.
- Data presented in Section 1.3 indicates that during the time period of February 2011 to January 2012, the WWTP was able to store and treat all facility process and stormwater and remain in compliance. WWTP compliance is based on meeting current MSOP effluent limits and WWTP operational capacities.

3.2 SOURCE IDENTIFICATION

Initial source identification entailed evaluating the potential sources of metals loading identified in Figure 3-1. Sampling was conducted to determine areas that are contributing to loading. Sampling was conducted in accordance with the Surface Water Sampling and Analysis Plan, The Doe Run Company, Southeast Missouri Operations, Water Quality (SWSAP, LimnoTech, 2010a) and the Industrial Stormwater Monitoring and Sampling Guide (EPA, 2009). Additional sampling will be conducted as required to identify additional sources and confirm the results of initial source identification efforts. All future sampling will be conducted in accordance with the SWSAP (LimnoTech, 2010a). To determine loading, flow will be collected in conjunction with sampling wherever possible/appropriate.

The list of target metals for the Herculaneum Smelter as presented in the Master SWMP (LimnoTech, 2010b) is as follows:

- Arsenic (As);
- Cadmium (Cd);
- Copper (Cu);
- Lead (Pb);
- Silver (Ag); and
- Zinc (Zn).

NPDES permit MO-0000281 also includes quarterly monitoring for Antimony (Sb) and Thallium (Tl).

Source identification sampling was conducted in April 2011. The sample locations selected at the Herculaneum Smelter are presented in Figure 1-2 and described in Table 3-4:

Table 3-4: Herculaneum Smelter Sample Locations and Descriptions

Sample ID	Sample Location	Sample Description
HS-0-01	Re-used slag storage area drainage,	Consists of collected stormwater drainage from slag storage area.
HS-0-02	Truck wash	Mixture of SSA stormwater drainage, recycled Truck Wash and Ranney Well water.
HS-0-03	Strip Mill	Process water from Strip Mill.
HS-0-04	Acid Plant Sump	Mixture of stormwater and process water from upstream (HS-01, HS-02, HS-03).
HS-0-05	Change House	Plant sprinkler water.
HS-0-07	Sinter Sump	Process water from Sinter machine area.
HS-0-08	Bag House #5	Washdown water.
HS-0-09	Holding Basin	Combined flows from HS-01 to HS-04.
HS-0-10	South Tank	Effluent from Holding Basin.
HS-0-11	North Tank	Combination of South Tank and at times Thickener overflow – process water.

Sampling was generally conducted in a low to high metal content orientation, with metals being lower in concentration at the Truck Wash versus the North Tank. Overall, sampling results indicate that cadmium, lead and zinc are the primary metals impacting surface water at the Herculaneum Smelter. Concentrations of other metals sampled (arsenic, copper, mercury, nickel, selenium and thallium) were typically one to three orders of magnitude lower than cadmium, lead and zinc.

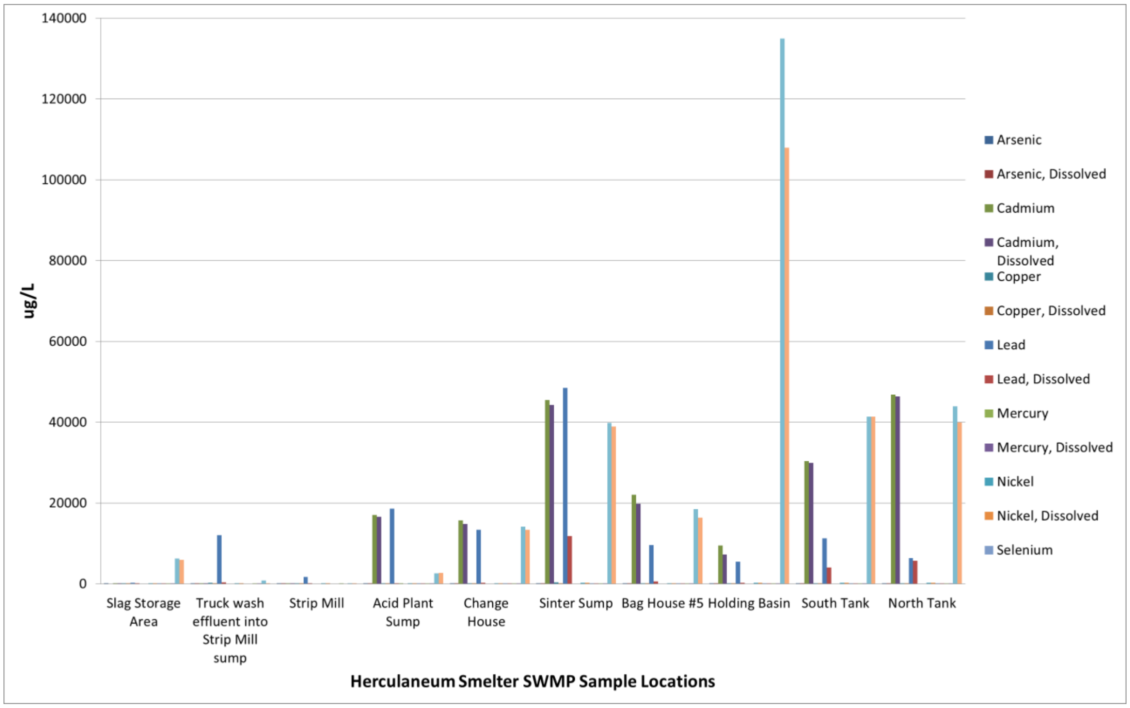
Results for individual sampling locations are summarized below:

- Slag storage area drainage (HS-0-01): The source of this water is from stormwater falling on the SSA and being collected in a drainage system for recycling at the Truck Wash. Sampling results indicate that slag storage area water contains relatively moderate amounts of zinc as compared to sources closer to the smelting activities. Concentrations of all other metals sampled, at HS-01, were one to three orders of magnitude lower than zinc.

- Truck Wash effluent (HS-0-02): This source represents recycled Truck Wash water and Ranney Well water. Sampling results indicate that Truck Wash effluent contains more lead than the Truck Wash sump. This is likely due to efficiency of the Truck Wash in the removal of lead from concentrate trucks. Concentrations of all other metals sampled were one to three orders of magnitude lower.
- Strip Mill sump (HS-0-03): This sample location represents process water from the Strip Mill. Sampling results indicate that the Strip Mill sump contains much lower concentrations of lead compared to other samples collected. Concentrations of all other metals sampled were one to three orders of magnitude lower than lead.
- Acid Plant sump (HS-0-04): This location collects stormwater from the concentrate unloading area and upstream sources at HS-01 and HS-02. Sampling results indicate that cadmium and lead concentrations increase in this sump. Lead concentrate is stored near this sump and may be the source of the lead. Concentrations of all other metals sampled were one to three orders of magnitude lower.
- Change House sump (HS-0-05): Sampling results indicate that inflows to the sump east of the Change House contain cadmium, lead and zinc. Likely sources include plant sprinkler water, stormwater and change house effluent. Concentrations of all other metals sampled were one to two orders of magnitude lower.
- Sinter Plant sump (HS-0-07): Sampling results indicate that inflows to the Sinter Plant sump contain cadmium, lead and zinc. Likely sources of these metals would be process water and stormwater. Concentrations of all other metals sampled were one to two orders of magnitude lower.
- Bag House #5 sump (HS-0-08): Sampling results indicate that inflows to the sump east of Bag House #5 contain cadmium and zinc. Likely sources would be washdown water from the handling of baghouse dust. Concentrations of all other metals sampled were one to three orders of magnitude lower.
- Holding Basin (HS-0-09): Sampling results indicate that inflows to the Holding Basin north of the granulation plant contain primarily zinc. Likely sources would be accumulation of upstream process water and some stormwater impacts. Zinc concentrations in Holding Basin samples were triple the concentrations observed in the next highest sample. Concentrations of all other metals sampled were one to three orders of magnitude lower.
- South and North Tanks (HS-0-10, HS-0-11): Sampling results from the South and North Tanks, which hold facility process and runoff water prior to treatment by the WWTP, were generally consistent with average values for combined in-plant upstream sample points. This area is not a source loading point as much as it is a holding tank for upstream processes and sources.

Sampling results are presented in Figure 3-2:

Figure 3-2: Herculaneum Smelter Source Identification Sampling Results



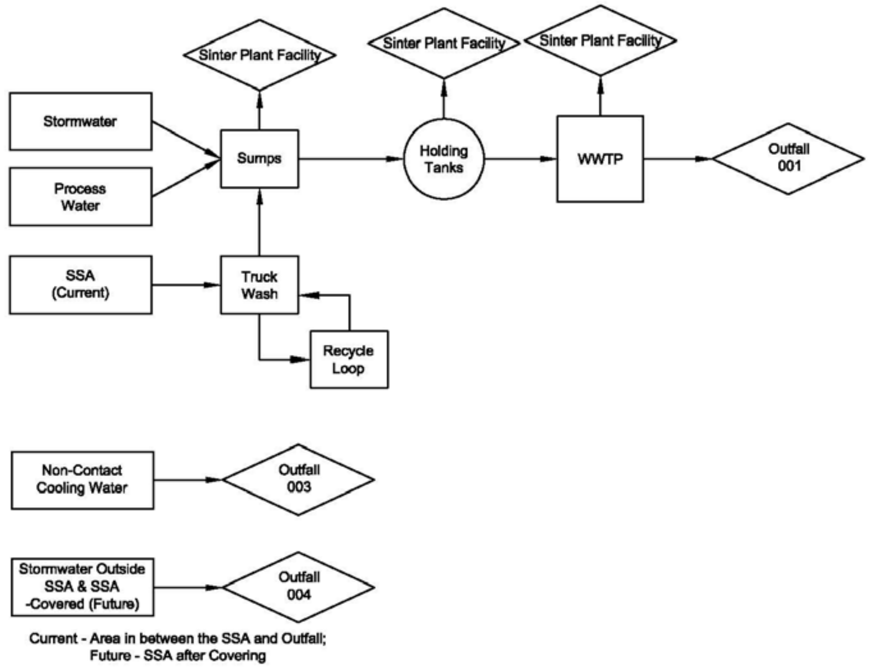
Additional sampling locations may be evaluated as determined by the SWMP Team to better understand the facility water treatment needs.

3.3 FATE AND TRANSPORT EVALUATION

Due to the nature of surface and process contact water flow at the Herculaneum Smelter facility, potential pathways and endpoints for fate and transport of metals are limited. The Herculaneum Smelter is, for the most part, a closed system where all flows report to the WWTP via conveyance in a piped drainage system. Exceptions to the closed nature of the system include non-contact cooling water which reports to Outfall 003 and stormwater that falls on the floodplain of Joachim Creek, outside of the SSA, which reports to Outfall 004. Water reporting to Outfall 004 will also include stormwater falling on the SSA after covering is complete. Outfalls 001 and 003 report to the Mississippi River. Outfall 004 reports to Joachim Creek directly above its confluence with the Mississippi River. Outfall 004 is subject to inundation by Mississippi River and Joachim Creek floodwaters.

A conceptual schematic fate and transport model is presented in Figure 3-3:

Figure 3-3: Herculaneum Smelter Conceptual Fate and Transport Model



Note: WWTP, sump and holding tank solids are reprocessed at the sinter plant or shipped to an appropriate facility.

Conceptual water flow is presented in Figure 3-1. Flow of the facility's metals load to the WWTP occurs entirely via the piped drainage system. Opportunities for metals to bypass the WWTP and be transported via alternate pathways are limited to inundation by the Mississippi River during extreme flood events. The last event of this magnitude occurred in 1993, when Joachim flood waters impacted the SSA prior to construction of the slag berm. The main smelter facility area north of the SSA is located in Flood Zone X. FEMA describes Flood Zone X as an area above the 500-year flood. The SSA is located in FEMA Flood Zone AE, which includes areas subject to inundation by the 1-percent-annual-chance (100-year) flood event as determined by FEMA.

Potential endpoints for metals fate are limited to:

- Settling in the sumps and holding basins upstream of the WWTP (solids are reprocessed or shipped to a treatment facility for processing),
- Removal by the WWTP, (solids are reprocessed or shipped to treatment facility for processing),
- Bound in slag and transported to SSA; and
- Discharge to waters of the State via regulated MSOP Outfalls.

The ultimate fate of the vast majority of total and dissolved metals entering surface water at the Herculaneum Smelter facility is removal by the WWTP. A much smaller fraction of the facility's total metals load is removed prior to reaching the WWTP via settling in the various sumps and holding basins located throughout the facility. These materials are removed by periodic cleaning of the sumps/tanks and reprocessing in the smelter.

The approximate efficiency of the WWTP was examined by comparing cadmium, lead and zinc concentrations in WWTP Forebay samples to WWTP effluent samples reported in the facility's monthly Discharge Monitoring Reports. Variations in concentration, flow and travel time through the WWTP will directly impact the accuracy of the efficiencies presented below:

Table 3-5: Approximate Daily Average WWTP Efficiencies

Metal	*Influent Load lb/day*[1]	*Effluent Load lb/day*[2]	*Removal Efficiency Percent (%)*
Cadmium	203.579	0.206	99.97
Lead	208.55	0.011	99.99
Zinc	357.757	0.039	99.99

Notes:
[1] – Influent loading calculated from Forebay samples collected December 13, 2011.
[2] – Effluent loading based on average values from SVG filters on December 13, 2011.

The data presented in Table 3-3 indicates high rates of removal. It is unlikely that improved treatment will be able to increase removal rates significantly. Source reduction measures will require monitoring during implementation to gauge effectiveness.

3.4 SOURCE REDUCTION & POLLUTION PREVENTION OPPORTUNITIES

This Section presents short and long term activities that have either already been implemented or are being planned to improve surface water quality. Work described in this Section includes projects that are focused on and/or directly related to improving facility surface water quality. Improvements to surface water quality will be focused on reduction of cadmium loading where possible. However, it is anticipated that general, cumulative decreases in metals loading will benefit the goal of reducing cadmium loading. This Section may be updated as additional measures are planned and implemented.

3.4.1 Short Term Control Measures

3.4.1.1 Slag Storage Area Water Management Plan

The Slag Storage Area Water Management Plan (SSAWMP, RMC, 2011a) was prepared to report on water management activities conducted by Doe Run in the Slag Storage Containment Area (SSA). The SSAWMP was submitted to EPA on January 31, 2011and revised and re-submitted on June 30, 2011.

The SSA containment system is designed to collect stormwater runoff from the SSA and transmit the water to a sump near the southeast area of the SSA. Submersible pumps located in the SSA sump deliver water from the sump to the Truck Wash.

The SSAWMP provides a general discussion on SSA water characteristics, analytical results for water contained in the SSA drainage collection system, a description of the effective end use (recycling) of the collected water and an implementation schedule for the management of the SSA stormwater collection system. The plan has been implemented, and adjustments such as water collection and redundant pumping have been made to enhance overall water management in the SSA.

3.4.1.2 Truck Wash Water Recycling

The Truck Wash Water Recycling Plan (LimnoTech, 2010c) describes recycling of water within the truck wash as well as reuse of water from the SSA containment system. Recycling conserves water usage and reduces pollutant loading to the WWTP. Water conservation will be accomplished by replacing up to 75 gpm of Ranney well water with stormwater from the SSA. Reductions in pollutant loading will be accomplished by filtering the wash water. Filtering reduces the amount of suspended metals, including cadmium, from water reporting to the WWTP. The Truck Wash Water Recycling Plan was submitted to the EPA and MDNR on September 9, 2010. The plan was approved by EPA without comments on October 22, 2010. The Truck Wash water recycling system is currently in-use.

3.4.1.3 North and South Tank Stem Wall and Sump

The existing North-South tank stormwater and process water surge tank has been modified by raising the concrete wall four feet on the North, East, and South sides to complement the existing wall on the West side. As a result, the overall maximum tank surge capacity has been increased by four feet. At the same time a new overflow control pump sump with a diesel powered pump has been added to the NE corner of the tank system. This pump will transfer excessive surge water regardless of plant power interruption to a one million gallon storm surge tank discussed below. Based on using three of the four feet, the stem wall has effectively increased storm surge capacity by the following volumes:

- 139,340 gallons (or 18,627 cubic feet) in the North Tank; and
- 107,921 gallons (or 14,427 cubic feet) in the South Tank.

The benefits of this increase in capacity are discussed in relation to reasonably anticipated storm events in Section 3.1.1.

3.4.1.4 One-Million Gallon Storm Surge Tank (#9 Tank)

Site stormwater capacity has been increased with the conversion of a one-million gallon former process tank into a stormwater surge tank system. The tank reduces the potential impacts of stormwater surges and potential overloading on the wastewater treatment plant (WWTP). Reducing the potential for overloading the WWTP will enable the facility to stay within the typical operational capacity and discharge within permitted limits for all metals. Doe Run received a Construction Permit Waiver from the State of Missouri to complete this project. The system became operational in October 2011.

In conjunction with the #9 one million gallon water storage tank project, a new pumping system has been commissioned in the fall of 2011 that pumps water from the South Tank by a new floating pontoon pump system to the 80 foot thickener at approximately 1100 gpm. The thickener is used to remove excessive solids. Water then overflows the thickener to a return water tank where approximately 400 to 500 gpm is pumped to the smelter's WWTP and the excess is returned by gravity through a piping system to the North tank. In the event of a storm surge wherein the normal working level of the North-South tank may be exceeded a new 600 gpm transfer pump located at the return water tank is utilized to pump the excess water to the #9 tank rather than let it return by gravity to the North tank. Should there be a total plant power failure then the diesel pump system will automatically start and transfer storm surge water to the #9 tank. In addition, the new floating pontoon pump is designed to allow the South tank to be pumped down to within four feet of the tank bottom thus increasing water holding capacity by 323,764 gallons.

3.4.1.5 Lime Tank

An additional lime tank was added to the headworks at the WWTP system in May, 2010, allowing for improved pH control. This improvement has been implemented to reduce overall metals discharge, including cadmium.

3.4.1.6 Evaluation of Reagents Used in the WWTP

Water treatment studies in 2010 also included an investigation of reagents, flocculation agents and polymer used in the WWTP. The intent of the study was to examine potential increases in WWTP efficiency. Results of the reagent study indicated that the current water treatment chemicals are effective at removing metals in the WWTP. The results of all the studies were submitted to EPA on July 1, 2010.

3.4.1.7 Current Surface Water Management Projects

Over the past six months Doe Run has initiated two studies focused on potential future loading demands on the WWTP. First, a Water Characterization Study (Water Study) was initiated to look at current loading information and estimate future loading during the potential transition period from pyrometallurgical processing to hydrometallurgical loading during the potential future operations at the facility (after smelter shut-down and decommissioning). The primary goal of the study is to evaluate whether the WWTP will have sufficient treatment capacity to meet effluent limits during the potential transitional and future operational periods described below:

Transitional Phase 1 Facility operations which assume:

- Pyrometallurgical operations;
- Construction of new technology; and
- New technology process start-up.

Transitional Phase 2 Facility operations which assume:

- Shutdown of pyrometallurgical operations;
- Demolition and removal of pyrometallurgical equipment; and
- New technology process operation.

Future operations which assume:

- New technology process operation; and
- Light industrial use of the facility.

The Water Study utilizes existing metal loading data at the inflow to the Forebay and DMR data for the WWTP 001 effluent. Results of the study indicate that loading to the WWTP may increase during Transitional Phase 2. It is during this phase that demolition of the existing facility and operation of the new technology concurrently may increase loading to the WWTP. The Water Study report will be finalized pursuant to the implementation schedule in Section 4.

Doe Run has initiated a second study based on recommendations identified during the Water Study. As stated previously, this study will be a phased study that will first collect and evaluate further data recommended by RMC to evaluate future potential loading to the WWTP. This phase will include, but may not be limited to, collection of additional flow and chemistry at key process steps, updating the flow data in the 2008 Water Balance Report, evaluating process time in the WWTP, for the transitional and future operations at the facility. This phased study and associated reports will be completed pursuant to the schedule in Section 4.

3.4.1.8 Cadmium Project

The cadmium project consists of packaging and selling of cadmium products located primarily in the dust from the ESP and baghouse. This project was initiated in December of 2010. Packaging and selling the cadmium products will reduce cadmium in the ventilation and water system. DMRs and data collected as part of the SWMP indicate that cadmium is a concern for compliance with MSOP effluent limits. During the smelting process fume and other airborne emissions are captured in the facility ventilation system and collect as fine dust products containing lead and other valuable metals. The Number 5 baghouse and the electrostatic precipitator (ESP) are the primary locations where the metal laden dusts collect.

The dust products are reprocessed in the sinter machine and blast furnace for lead and other primary products. During the reprocessing the dust products are moved from the baghouse and ESP to the smelting facilities. Water is used to control the dust during this process and to clean up after the materials have been transferred. The facility Lead SIP requires that Doe Run use water to maintain ambient air quality. Over time and by continual reprocessing of the dust products cadmium has become concentrated. It is estimated that cadmium has built up in the ventilation dusts for the past eight to ten years. Doe Run has initiated this project, which will be ongoing, to extract and market the cadmium product. It is expected that cadmium concentrations will decrease at the Forebay influent gradually. Forebay influent samples will be collected weekly to track this predicted long term trend.

3.4.2 Long-Term Control Measures

Doe Run has elected to permanently cease pyrometallurgical operations at the Herculaneum Smelting facility in accordance with the following schedule as provided the Multi-Media Consent Decree:

- Retire and permanently cease operation of the Sintering Machine and ancillary equipment by December 31, 2013;

- Retire and permanently cease operation of the Sulfuric Acid Plant by December 31, 2013; and
- Retire and permanently cease operation of the Blast Furnaces by April 30, 2014.

The cessation of these operations will result in a substantial reduction of metal loading from the Sintering Machine and Blast Furnaces. Additional source reductions are expected by the cessation of storage, handling and processing of lead concentrates, which in turn will result in a direct reduction of metal loading to the WWTP. DRC believes that reduced cadmium loading will allow the WWTP to consistently meet final cadmium effluent limits.

3.4.3 Enhanced Storage/Treatment Options

Modification of existing storage/treatment practices or implementation of new enhanced storage/treatment options are not being considered at this time. If short and long term reduction efforts, as previously described, are not shown to be effective and the facility is not meeting regulatory discharge requirements, then:

- Existing facilities may be reviewed to determine if they are being optimized;
- Opportunities for retrofits of those facilities may be considered; and
- New enhanced storage/treatment options may be evaluated with respect to effectiveness, feasibility and cost.

3.4.4 Best Management Practices

To the extent that they are necessary and economically feasible, as appropriate, the following general source control Best Management Practices (BMPs) will be implemented:

- Efficient use of water for, equipment cleaning and street sweeping to minimize runoff generated by these processes; and
- Monthly meetings of the Surface Water Management Team, described in Section 2.1. The team focus is to develop solutions to current and future water management issues.

The following BMPs are addressed by the facility SWPPP:

- Reduction of surface water contact with metals sources to the greatest degree practical. Wherever possible, industrial processes and material storage occurs indoors to minimize contact with stormwater;
- Diversion of stormwater runoff away from areas known to have elevated levels of metals;

- Tanks, secondary containment structures and chemical storage containers are inspected for damage or leakage at least every other week;
- All aboveground fuel and oil tanks have secondary spill/overfill containment. Spills will be addressed pursuant to the facility's SPCC plan. Spill cleanup waste materials are properly disposed of in accordance with applicable regulations;
- Coke, furnace additive and ore concentrate storage areas are inspected once per quarter to ensure that any stormwater coming in contact with stored materials drains to WWTP;
- Interior and exterior areas of truck wash are visually inspected once per quarter to ensure proper equipment use and that water is directed to the WWTP;
- Slag storage area is inspected once per quarter to ensure proper functioning of stormwater collection system and structural integrity of SSA berm;
- The facility has structural control measures to minimize industrial activity coming into contact with stormwater. These include drainage channels, stormwater inlets and pipes that are used to convey stormwater to the WWTP;
- Implementation of good housekeeping measures to ensure that all work areas are kept as clean as possible, and in particular where materials ;
- Waste receptacles with a capacity of 3 cubic yards or less have lids to prevent stormwater from contacting their contents. Waste receptacles with a capacity of 3 cubic yards or more are inspected daily for leaks and trash present outside the receptacle;
- Upon hire and at least once each calendar year, employees who work in areas where industrial activities are exposed to stormwater, or who are responsible for implementing activities necessary to meet the conditions of the SWPPP (e.g., inspectors, maintenance personnel, all members of the Pollution Prevention Team), receive training which covers the specific control measures, monitoring, inspection, planning, reporting, and documentation requirements of the SWPPP;
- Scheduling of maintenance on an ongoing and systematic basis. Regular scheduled maintenance of sumps, conveyance systems, outdoor storage areas and other work areas will minimize the buildup of materials that have the potential to increase loading; and
- Any and all runoff that may occur from exposed industrial areas is routed to the WWTP.

3.5 EVALUATION OF THE EFFECTIVENESS OF IMPLEMENTED CONTROLS (MONITORING)

- The facility is in substantial compliance with its MSOP effluent limits. Therefore evaluation of implemented controls will consist of the following monitoring program:Weekly WWTP influent monitoring (Forebay);

- Weekly monitoring at NPDES locations;
- Quarterly groundwater monitoring at the SSA; and
- Special project monitoring for source reduction efforts.

Additional monitoring will be evaluated by the Herculaneum Surface Operations Water Quality management team and implemented as necessary.

3.6 TRAINING

Initial training will be conducted to educate facility personnel in the first quarter of 2012, concurrently with SWPPP training. Annual training will be conducted thereafter for both programs. The training will provide a consistent set of guidelines and promote a corporate culture that recognizes the need to maintain compliance with all applicable permits and the importance of water management.

The training will help to ensure that all employees and contractors will be trained to perform tasks related to water management, pollution prevention and waste minimization. Training will ensure that the proper decisions are being made on all aspects of smelting and water management processes.

Training will be conducted to provide an understanding of project goals and the necessary skill-set required to evaluate and implement controls and will include.

- The need for surface water management (including the environmental need);
- Best management practices;
- Specific water management actions implemented or planned;
- Applicable water management protocols or standard operating procedures;
- Inspections;
- Recordkeeping; and
- Communications and team responsibilities.

3.7 TRACKING/RECORDKEEPING

A Storm Water Pollution Prevention Plan (SWPPP) was developed and implemented for the Herculaneum Smelter in April 2011. The Herculaneum Environmental Department continues to implement the SWPPP. In addition to the SWPPP, water management measures contained in this SWMP will be inspected quarterly and the inspections will be documented and kept on-site at the Herculaneum Smelter. Inspection of other water management measures, such as BMPs, will be completed and documented and kept on-site pursuant to the SWPPP.

3.8 ADAPTIVE MANAGEMENT

This plan will be revised by the water management team annually for the first two years of implementation and updated otherwise as needed. The first plan review and update will occur in January of 2013. After the first two years, the frequency of review and updated will be reassessed. The most current version of this plan will be kept on file at the Herculaneum Smelter.

4. IMPLEMENTATION SCHEDULE

This Section presents the implementation schedule for surface water management at the facility.

As described in Section 3.4 proactive implementation of short and long term control strategies of process, procedures and studies have been undertaken or are planned to manage and improve water quality at the facility. The schedule for water management at Herculaneum is presented in Table 4-1. This schedule is based on the best information available as of the date of this plan.

Table 4-1: Implementation Schedule for Surface Water Management Plan Activities at the Herculaneum Facility.

Action	Dec. 2011	Jan. 2012	Feb 2012	Mar. 2012	April 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec 2012	Dec. 31 2013	April 30 2014
Training								Ongoing							
SWMP INSPECTIONS															
Sampling															
SWMP Team	Monthly Meetings														
Water Characterization Study															
Water Process Determination Phase I															
Water Process Determination Phase II								To be determined based on Phase I							
Cadmium Project															
Best Mgmt. Practices	Ongoing														
Record Keeping	Ongoing														
Plan Review & Update															
Cease sinter plant, acid plant															
Cease Blast Furnace															

Short term projects that have been completed include the following;

Slag Storage Area Water Management Plan
North and South Tank Stem Wall
Lime Tank

Truck Wash Recycling
One-Million Gallon Storm Surge Tank
Evaluation of Reagents Used in the

This page is blank to facilitate double sided printing.

5. REFERENCES

Barr Engineering, (Barr), 2007, Remedial Action Work Plan, Herculaneum Slag Storage Area (RAWP)

Doe Run Company, Herculaneum Smelter Plant Water Balance, 2008 Special Report

Huff, Floyd A., A, and James R. Angel, Rainfall Frequency Atlas of the Midwest, Illinois State Water Survey, Champaign, Bulletin 71, 1992.

National Climatic Data Center (NCDC), http://www.ncdc.noaa.gov/oa/ncdc.html

LimnoTech, 2010a, Surface Water Sampling and Analysis Plan, The Doe Run Company.

LimnoTech, 2010b, Master Surface Water Management Plan, The Doe Run Company.

LimnoTech, 2010c, Doe Run Herculaneum Smelter Truck Wash Water Recycling Plan.

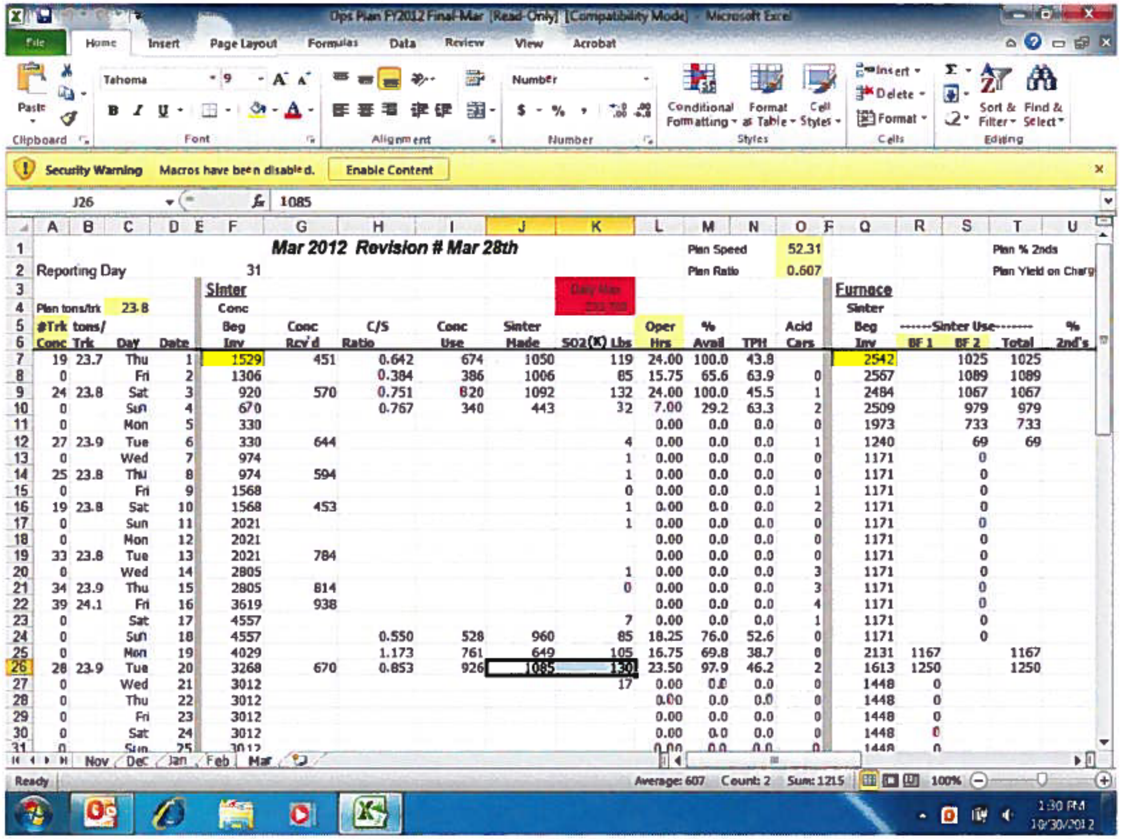
Resource & Environmental Management Consultants, Inc. (RMC), 2011a, Doe Run Company, Revised Slag Storage Area Water Management Plan.

Resource & Environmental Management Consultants, Inc. (RMC), 2011b, Doe Run Company, Water Characterization Study (Water Study).

United States Department of Agriculture, Natural Resources Conservation Service (NRCS), 1986, Urban Hydrology for Small Watersheds, TR-55 (TR-55).

United States Department of Energy, Argonne National Laboratory, Environmental Science Division (EVS). http://web.ead.anl.gov/resrad/datacoll/porosity.htm, (USDOE).

EXHIBIT AA



Mar 2012 Revision # Mar 28th

Reporting Day 31

Plan Speed 52.31

Plan Ratio 0.607

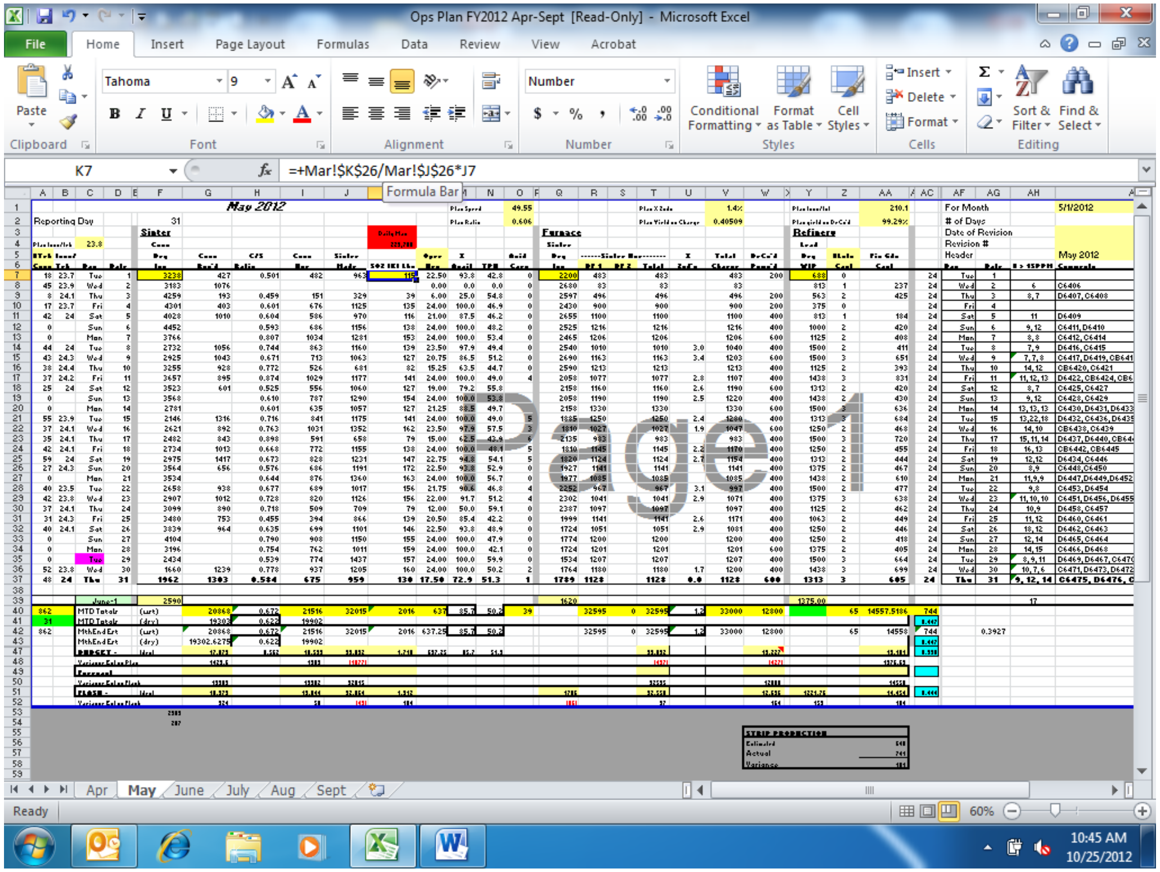
Plan % 2nds

Plan Yield on Charg

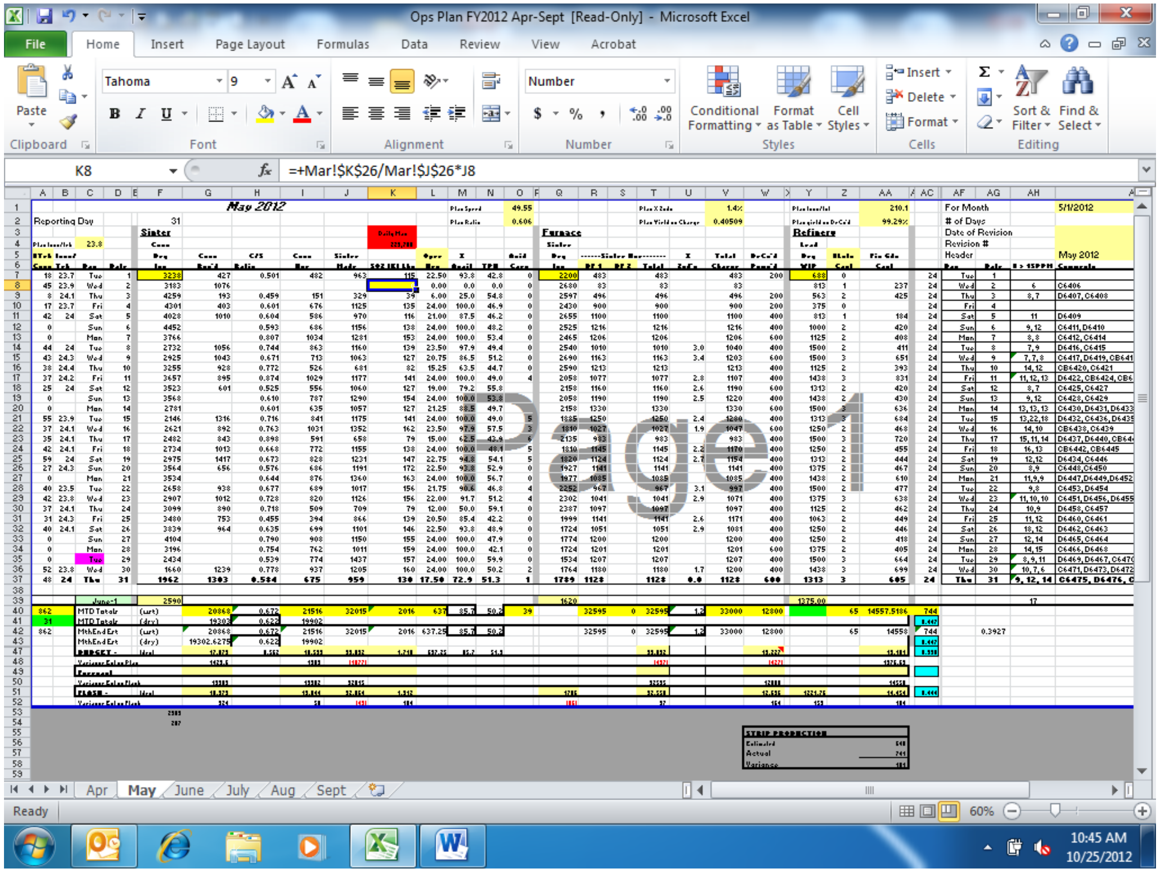
Plan tons/trk 23.8

Row	#Trk Conc	tons/ Trk	Day	Date	Sinter Conc Beg Inv	Conc Rcv'd	C/S Ratio	Conc Use	Sinter Made	SO2(X) Lbs	Oper Hrs	% Avail	TPH	Acid Cars	Furnace Sinter Beg Inv	Sinter Use BF 1	Sinter Use BF 2	Sinter Use Total	% 2nd's
7	19	23.7	Thu	1	1529	451	0.642	674	1050	119	24.00	100.0	43.8		2542		1025	1025	
8	0		Fri	2	1306		0.384	386	1006	85	15.75	65.6	63.9	0	2567		1089	1089	
9	24	23.8	Sat	3	920	570	0.751	820	1092	132	24.00	100.0	45.5	1	2484		1067	1067	
10	0		Sun	4	670		0.767	340	443	32	7.00	29.2	63.3	2	2509		979	979	
11	0		Mon	5	330						0.00	0.0	0.0	0	1973		733	733	
12	27	23.9	Tue	6	330	644				4	0.00	0.0	0.0	1	1240		69	69	
13	0		Wed	7	974					1	0.00	0.0	0.0	0	1171		0		
14	25	23.8	Thu	8	974	594				1	0.00	0.0	0.0	0	1171		0		
15	0		Fri	9	1568					0	0.00	0.0	0.0	1	1171		0		
16	19	23.8	Sat	10	1568	453				1	0.00	0.0	0.0	2	1171		0		
17	0		Sun	11	2021					1	0.00	0.0	0.0	0	1171		0		
18	0		Mon	12	2021						0.00	0.0	0.0	0	1171		0		
19	33	23.8	Tue	13	2021	784					0.00	0.0	0.0	0	1171		0		
20	0		Wed	14	2805					1	0.00	0.0	0.0	3	1171		0		
21	34	23.9	Thu	15	2805	814				0	0.00	0.0	0.0	3	1171		0		
22	39	24.1	Fri	16	3619	938					0.00	0.0	0.0	4	1171		0		
23	0		Sat	17	4557					7	0.00	0.0	0.0	1	1171		0		
24	0		Sun	18	4557		0.550	528	960	85	18.25	76.0	52.6	0	1171		0		
25	0		Mon	19	4029		1.173	761	649	105	16.75	69.8	38.7	0	2131	1167		1167	
26	28	23.9	Tue	20	3268	670	0.853	926	1085	130	23.50	97.9	46.2	2	1613	1250		1250	
27	0		Wed	21	3012					17	0.00	0.0	0.0	0	1448	0			
28	0		Thu	22	3012						0.00	0.0	0.0	0	1448	0			
29	0		Fri	23	3012						0.00	0.0	0.0	0	1448	0			
30	0		Sat	24	3012						0.00	0.0	0.0	0	1448	0			
31	0		Sun	25	3012						0.00	0.0	0.0	0	1448	0			

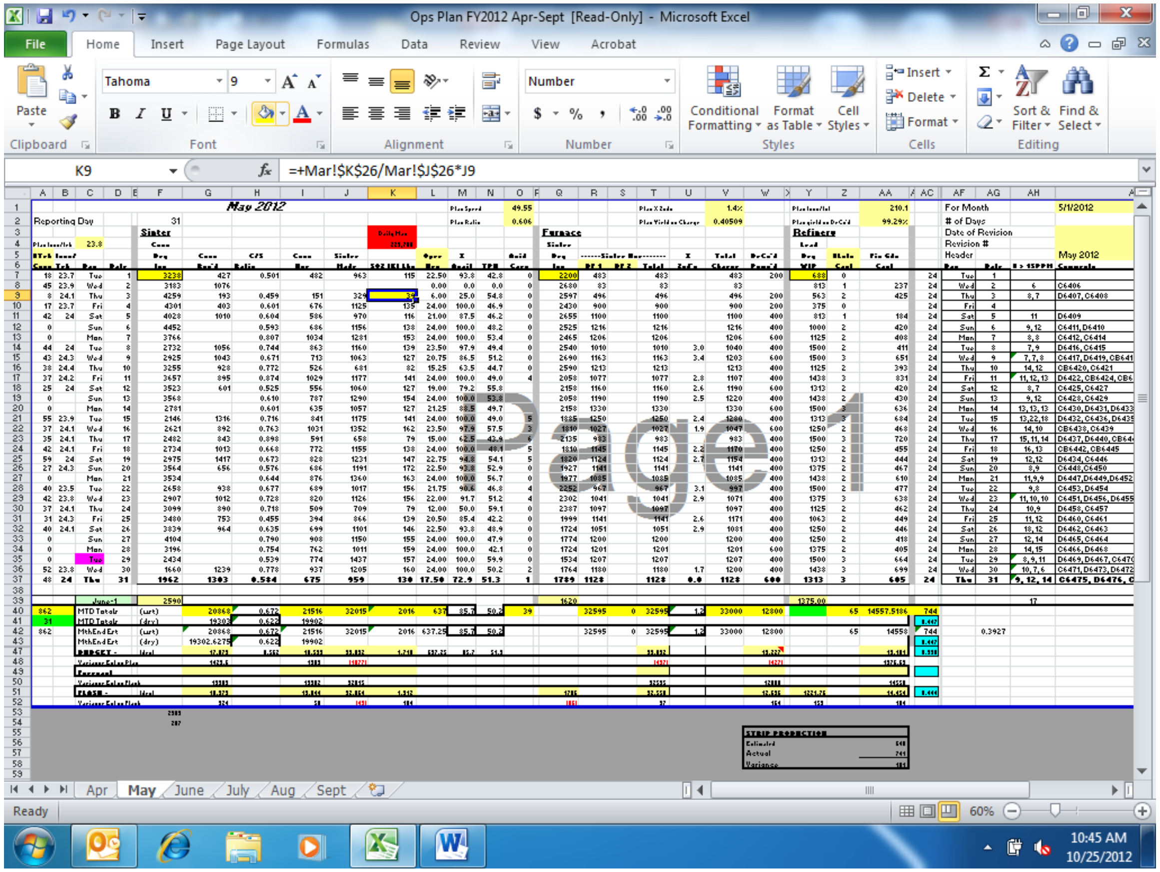
Nov Dec Jan Feb Mar



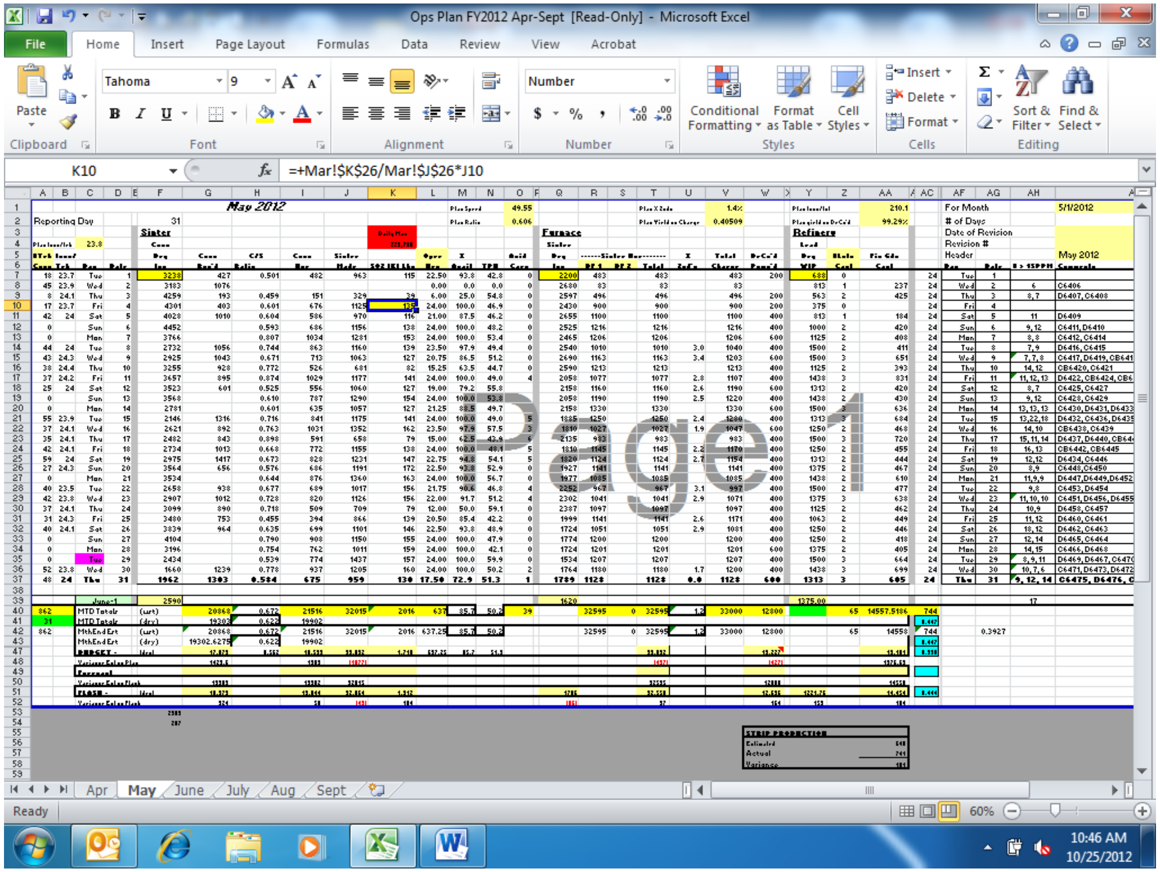
Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC	AF	AG	AH	AI
7	18	23.7	Tue	1	3238	427	0.501	482	963	115	22.50	93.8	42.8	0	2200	483		483		483	200	688	0		24	Tue	1		
8	45	23.9	Wed	2	3183	1076					0.00	0.0	0.0	0	2680	83		83		83		813	1	237	24	Wed	2	6	C6406
9	8	24.1	Thu	3	4259	193	0.459	151	329	39	6.00	25.0	54.8	0	2597	496		496		496	200	563	2	425	24	Thu	3	8,7	D6407, C6408
10	17	23.7	Fri	4	4301	403	0.601	676	1125	135	24.00	100.0	46.9	0	2430	900		900		900	200	375	0		24	Fri	4		
11	42	24	Sat	5	4028	1010	0.604	586	970	116	21.00	87.5	46.2	0	2655	1100		1100		1100	400	813	1	184	24	Sat	5	11	D6409
12	0		Sun	6	4452		0.593	686	1156	138	24.00	100.0	48.2	0	2525	1216		1216		1216	400	1000	2	420	24	Sun	6	9,12	C6411, D6410
13	0		Mon	7	3766		0.807	1034	1281	153	24.00	100.0	53.4	0	2465	1206		1206		1206	600	1125	2	408	24	Mon	7	8,8	C6412, C6414
14	44	24	Tue	8	2732	1056	0.744	863	1160	139	23.50	97.9	49.4	0	2540	1010		1010	3.0	1040	400	1500	2	411	24	Tue	8	7,9	D6416, C6415
15	43	24.3	Wed	9	2925	1043	0.671	713	1063	127	20.75	86.5	51.2	0	2690	1163		1163	3.4	1203	600	1500	3	651	24	Wed	9	7,7,8	C6417, D6419, CB641
16	38	24.4	Thu	10	3255	928	0.772	526	681	82	15.25	63.5	44.7	0	2590	1213		1213		1213	400	1125	2	393	24	Thu	10	14,12	CB6420, C6421
17	37	24.2	Fri	11	3657	895	0.874	1029	1177	141	24.00	100.0	49.0	4	2058	1077		1077	2.8	1107	400	1438	3	831	24	Fri	11	11,12,13	D6422, CB6424, CB6
18	25	24	Sat	12	3523	601	0.525	556	1060	127	19.00	79.2	55.8		2158	1160		1160	2.6	1190	600	1313	2	420	24	Sat	12	8,7	C6425, C6427
19	0		Sun	13	3568		0.610	787	1290	154	24.00	100.0	53.8		2058	1190		1190	2.5	1220	400	1438	2	430	24	Sun	13	9,12	C6428, C6429
20	0		Mon	14	2781		0.601	635	1057	127	21.25	88.5	49.7		2158	1330		1330		1330	600	1500	3	636	24	Mon	14	13,13,13	C6430, D6431, D6433
21	55	23.9	Tue	15	2146	1316	0.716	841	1175	141	24.00	100.0	49.0	5	1885	1250		1250	2.4	1280	400	1313	3	684	24	Tue	15	13,22,18	D6432, C6436, D6435
22	37	24.1	Wed	16	2621	892	0.763	1031	1352	162	23.50	97.9	57.5	3	1810	1027		1027	1.9	1047	600	1250	2	468	24	Wed	16	14,10	CB6438, C6439
23	35	24.1	Thu	17	2482	843	0.898	591	658	79	15.00	62.5	43.9	6	2135	983		983		983	400	1500	3	720	24	Thu	17	15,11,14	D6437, D6440, CB64
24	42	24.1	Fri	18	2734	1013	0.668	772	1155	138	24.00	100.0	48.1	5	1810	1145		1145	2.2	1170	400	1250	2	455	24	Fri	18	16,13	CB6442, CB6445
25	59	24	Sat	19	2975	1417	0.673	828	1231	147	22.75	94.8	54.1	5	1820	1124		1124	2.7	1154	400	1313	2	444	24	Sat	19	12,12	D6434, C6446
26	27	24.3	Sun	20	3564	656	0.576	686	1191	172	22.50	93.8	52.9	0	1927	1141		1141		1141	400	1375	2	467	24	Sun	20	8,9	C6448, C6450
27	0		Mon	21	3534		0.644	876	1360	163	24.00	100.0	56.7	0	1977	1085		1085		1085	400	1438	2	610	24	Mon	21	11,9,9	D6447, D6449, D6452
28	40	23.5	Tue	22	2658	938	0.677	689	1017	156	21.75	90.6	46.8	4	2252	967		967	3.1	997	400	1500	2	477	24	Tue	22	9,8	C6453, D6454
29	42	23.8	Wed	23	2907	1012	0.728	820	1126	156	22.00	91.7	51.2	4	2302	1041		1041	2.9	1071	400	1375	3	638	24	Wed	23	11,10,10	C6451, D6456, D6455
30	37	24.1	Thu	24	3099	890	0.718	509	709	79	12.00	50.0	59.1	0	2387	1097		1097		1097	400	1125	2	462	24	Thu	24	10,9	D6458, C6457
31	31	24.3	Fri	25	3480	753	0.455	394	866	139	20.50	85.4	42.2	0	1999	1141		1141	2.6	1171	400	1063	2	449	24	Fri	25	11,12	D6460, C6461
32	40	24.1	Sat	26	3839	964	0.635	699	1101	146	22.50	93.8	48.9	0	1724	1051		1051	2.9	1081	400	1250	2	446	24	Sat	26	18,12	D6462, C6463
33	0		Sun	27	4104		0.790	908	1150	155	24.00	100.0	47.9	0	1774	1200		1200		1200	400	1250	2	418	24	Sun	27	12,14	D6465, C6464
34	0		Mon	28	3196		0.754	762	1011	159	24.00	100.0	42.1	0	1724	1201		1201		1201	600	1375	2	405	24	Mon	28	14,15	C6466, D6468
35	0		Tue	29	2434		0.539	774	1437	157	24.00	100.0	59.9	0	1534	1207		1207		1207	400	1500	3	664	24	Tue	29	8,9,11	D6469, D6467, C6470
36	52	23.8	Wed	30	1660	1239	0.778	937	1205	160	24.00	100.0	50.2	2	1764	1180		1180	1.7	1200	400	1438	3	699	24	Wed	30	10,7,6	C6471, D6473, D6472
37	**48**	**24**	**Thu**	**31**	**1962**	**1303**	**0.584**	**675**	**959**	**130**	**17.50**	**72.9**	**51.3**	**1**	**1789**	**1128**		**1128**	**0.0**	**1128**	**600**	**1313**	**3**	**605**	**24**	**Thu**	**31**	**9, 12, 14**	**C6475, D6476, C**
39			June-1		2590										1620							1375.00						17	
40	862		MTD Totals		(wet)	20868	0.672	21516	32015	2016	637	85.7	50.2	39		32595	0	32595	1.3	33000	12800		65	14557.5186	744				
41	31		MTD Totals		(dry)	19303	0.622	19902																	0.447				
42	862		MthEnd Est		(wet)	20868	0.672	21516	32015	2016	637.25	85.7	50.2			32595	0	32595	1.3	33000	12800		65	14558	744		0.3927		
43			MthEnd Est		(dry)	19302.6275	0.622	19902																	0.447				

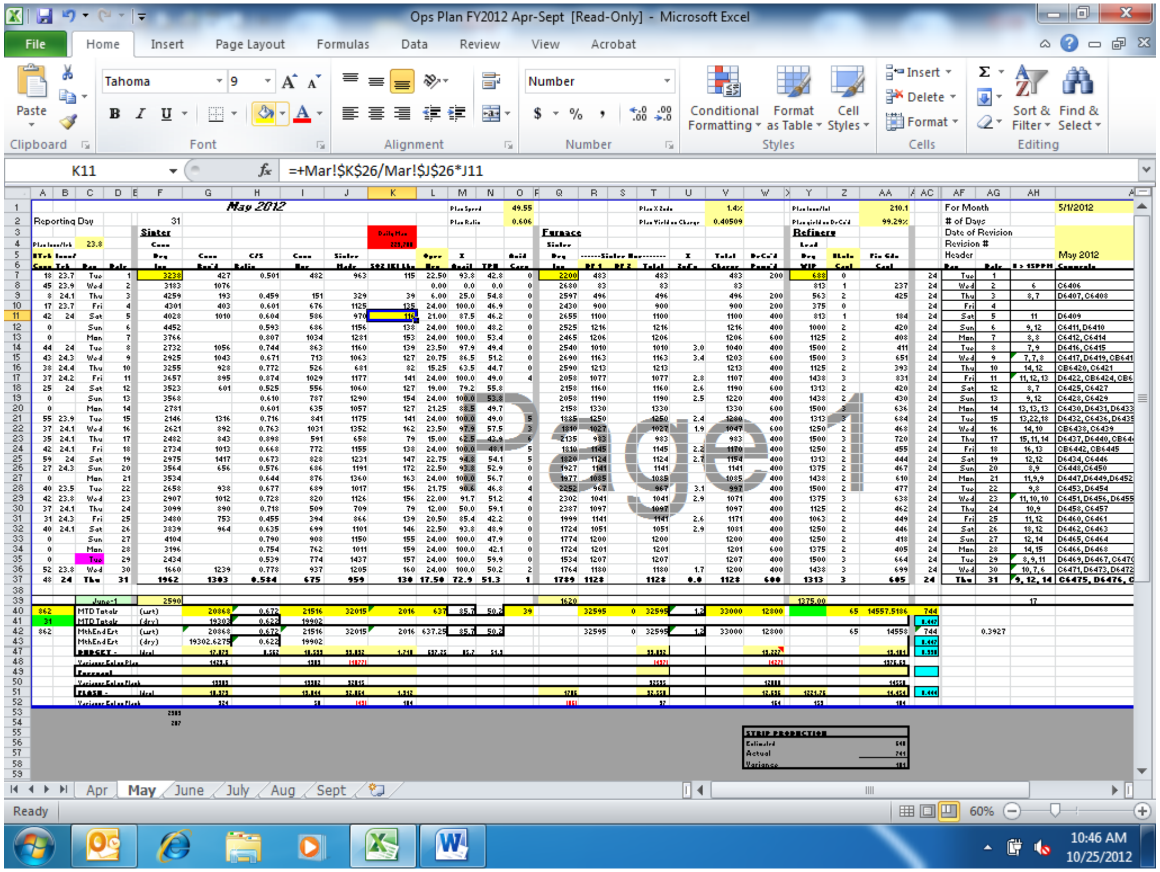


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K8
=+Mar!$K$26/Mar!$J$26*J8
May 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:45 AM
10/25/2012

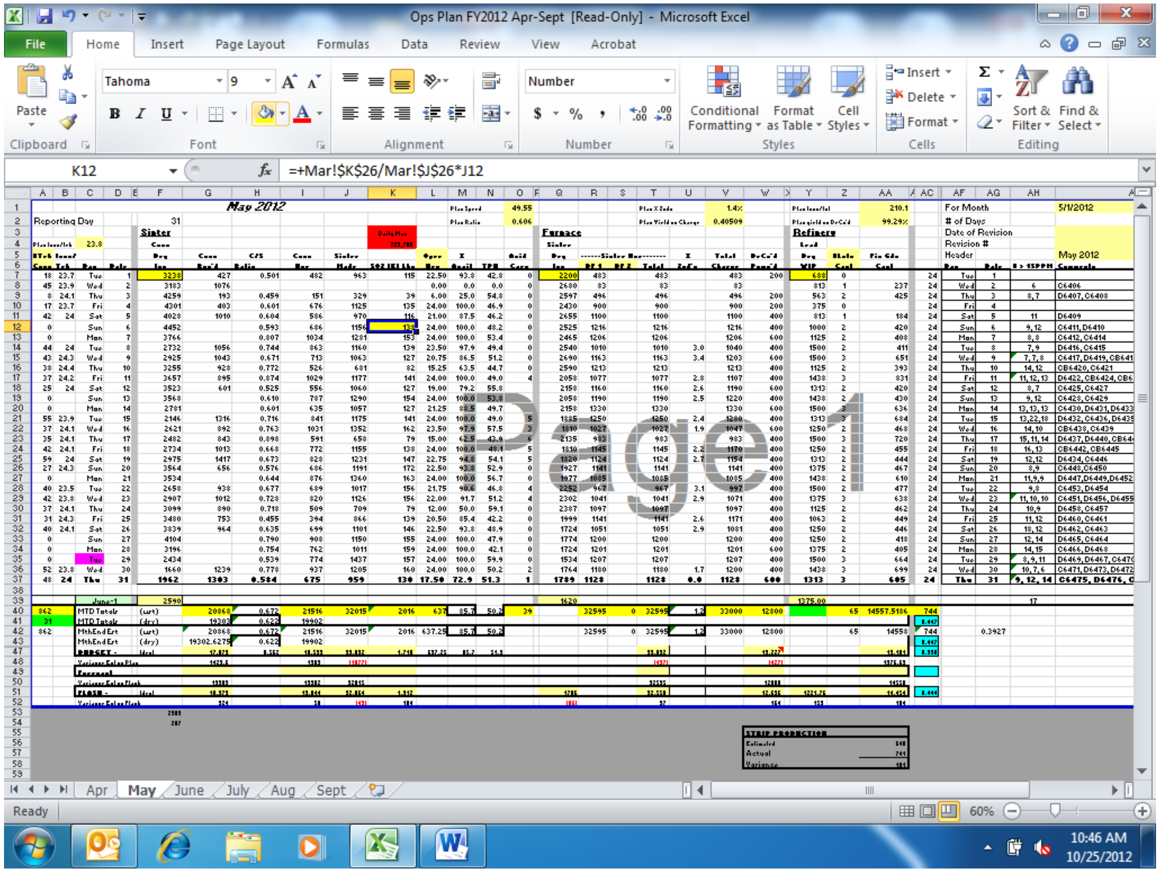


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K9
=+Mar!$K$26/Mar!$J$26*J9
May 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page 1
STRIP PRODUCTION
Apr
May
June
July
Aug
Sept
Ready
60%
10:45 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Tahoma
Number
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
K10
=+Mar!$K$26/Mar!$J$26*J10
May 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page 1
STRIP PRODUCTION
Apr
May
June
July
Aug
Sept
Ready
60%
10:46 AM
10/25/2012



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Tahoma
9
Number
Paste
Clipboard
Font
Alignment
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
K11
=+Mar!$K$26/Mar!$J$26*J11
May 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page 1
STRIP PRODUCTION
Apr
May
June
July
Aug
Sept
Ready
60%
10:46 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K12
=+Mar!$K$26/Mar!$J$26*J12
May 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
STRIP PRODUCTION
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:46 AM
10/25/2012

Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | Acrobat

Paste | Tahoma | 9 | Number | Conditional Formatting | Format as Table | Cell Styles | Insert | Delete | Format | Sort & Filter | Find & Select

Clipboard | Font | Alignment | Number | Styles | Cells | Editing

K13 | =+Mar!$K$26/Mar!$J$26*J13

May 2012

Row				
1	May 2012	Plan Speed 49.55	Plan X ZnCo 1.4%	Plan lead/lot 210.1	For Month 5/1/2012
2	Reporting Day 31	Plan Ratio 0.606	Plan Yield on Charge 0.40509	Plan yield on DeCu'd 99.29%	# of Days
3	Sinter	Daily Max	Furnace	Refinery	Date of Revision
4	Plan lead/tek 23.8	225,700			Revision #
5					Header May 2012

Row	A #Tek Cons	B Lead/Tek	C Day	D Date	F Sinter Conc Dry Inv	G Conc Rec'd	H C/S Ratio	I Conc Use	J Sinter Made	K SO2 (K) Lbs	L Oper Hrs	M % Avail	N TPH	O Acid Cars
7	18	23.7	Tue	1	3238	427	0.501	482	963	115	22.50	93.8	42.8	0
8	45	23.9	Wed	2	3183	1076					0.00	0.0	0.0	0
9	8	24.1	Thu	3	4259	193	0.459	151	329	39	6.00	25.0	54.8	0
10	17	23.7	Fri	4	4301	403	0.601	676	1125	135	24.00	100.0	46.9	0
11	42	24	Sat	5	4028	1010	0.604	586	970	116	21.00	87.5	46.2	0
12	0		Sun	6	4452		0.593	686	1156	138	24.00	100.0	48.2	0
13	0		Mon	7	3766		0.807	1034	1281	153	24.00	100.0	53.4	0
14	44	24	Tue	8	2732	1056	0.744	863	1160	139	23.50	97.9	49.4	0
15	43	24.3	Wed	9	2925	1043	0.671	713	1063	127	20.75	86.5	51.2	0
16	38	24.4	Thu	10	3255	928	0.772	526	681	82	15.25	63.5	44.7	0
17	37	24.2	Fri	11	3657	895	0.874	1029	1177	141	24.00	100.0	49.0	4
18	25	24	Sat	12	3523	601	0.525	556	1060	127	19.00	79.2	55.8	
19	0		Sun	13	3568		0.610	787	1290	154	24.00	100.0	53.8	
20	0		Mon	14	2781		0.601	635	1057	127	21.25	88.5	49.7	
21	55	23.9	Tue	15	2146	1316	0.716	841	1175	141	24.00	100.0	49.0	5
22	37	24.1	Wed	16	2621	892	0.763	1031	1352	162	23.50	97.9	57.5	3
23	35	24.1	Thu	17	2482	843	0.898	591	658	79	15.00	62.5	43.9	6
24	42	24.1	Fri	18	2734	1013	0.668	772	1155	138	24.00	100.0	48.1	5
25	59	24	Sat	19	2975	1417	0.673	828	1231	147	22.75	94.8	54.1	5
26	27	24.3	Sun	20	3564	656	0.576	686	1191	172	22.50	93.8	52.9	0
27	0		Mon	21	3534		0.644	876	1360	163	24.00	100.0	56.7	0
28	40	23.5	Tue	22	2658	938	0.677	689	1017	156	21.75	90.6	46.8	4
29	42	23.8	Wed	23	2907	1012	0.728	820	1126	156	22.00	91.7	51.2	4
30	37	24.1	Thu	24	3099	890	0.718	509	709	79	12.00	50.0	59.1	0
31	31	24.3	Fri	25	3480	753	0.455	394	866	139	20.50	85.4	42.2	0
32	40	24.1	Sat	26	3839	964	0.635	699	1101	146	22.50	93.8	48.9	0
33	0		Sun	27	4104		0.790	908	1150	155	24.00	100.0	47.9	0
34	0		Mon	28	3196		0.754	762	1011	159	24.00	100.0	42.1	0
35	0		Tue	29	2434		0.539	774	1437	157	24.00	100.0	59.9	0
36	52	23.8	Wed	30	1660	1239	0.778	937	1205	160	24.00	100.0	50.2	2
37	**48**	**24**	**Thu**	**31**	**1962**	**1303**	**0.584**	**675**	**959**	**130**	**17.50**	**72.9**	**51.3**	**1**
39			June-1		2590									
40	862		MTD Totals	(wt)		20868	0.672	21516	32015	2016	637	85.7	50.2	39
41	31		MTD Totals	(dry)		19303	0.622	19902						
42	862		MthEnd Est	(wt)		20868	0.672	21516	32015	2016	637.25	85.7	50.2	
43			MthEnd Est	(dry)		19302.6275	0.622	19902						
47			BUDGET -	Ideal		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
48			Variance Est vs Plan			[illegible]		[illegible]	[illegible]					
49			Forecast											
50			Variance Est vs Flash			[illegible]		[illegible]	[illegible]					
51			FLASH -	Ideal		[illegible]		[illegible]	[illegible]	[illegible]				
52			Variance Est vs Flash			[illegible]		[illegible]	[illegible]	[illegible]				

Row	Q Furnace Sinter Dry Inv	R Sinter Use PF 1	S PF 2	T Total	U % ZnCo	V Total Charge	W DeCu'd Rec'd	Y Refinery Lead Dry WIP	Z Blade Cast	AA Fin Gds Cast	AC	AF Day	AG Date	AH # > 15PPM	AI Comments
7	2200	483		483		483	200	688	0		24	Tue	1		
8	2680	83		83		83		813	1	237	24	Wed	2	6	C6406
9	2597	496		496		496	200	563	2	425	24	Thu	3	8, 7	D6407, C6408
10	2430	900		900		900	200	375	0		24	Fri	4		
11	2655	1100		1100		1100	400	813	1	184	24	Sat	5	11	D6409
12	2525	1216		1216		1216	400	1000	2	420	24	Sun	6	9, 12	C6411, D6410
13	2465	1206		1206		1206	600	1125	2	408	24	Mon	7	8, 8	C6412, C6414
14	2540	1010		1010	3.0	1040	400	1500	2	411	24	Tue	8	7, 9	D6416, C6415
15	2690	1163		1163	3.4	1203	600	1500	3	651	24	Wed	9	7, 7, 8	C6417, D6419, CB641
16	2590	1213		1213		1213	400	1125	2	393	24	Thu	10	14, 12	CB6420, C6421
17	2058	1077		1077	2.8	1107	400	1438	3	831	24	Fri	11	11, 12, 13	D6422, CB6424, CB6
18	2158	1160		1160	2.6	1190	600	1313	2	420	24	Sat	12	8, 7	C6425, C6427
19	2058	1190		1190	2.5	1220	400	1438	2	430	24	Sun	13	9, 12	C6428, C6429
20	2158	1330		1330		1330	600	1500	3	636	24	Mon	14	13, 13, 13	C6430, D6431, D6433
21	1885	1250		1250	2.4	1280	400	1313	3	684	24	Tue	15	13,22,18	D6432, C6436, D6435
22	1810	1027		1027	1.9	1047	600	1250	2	468	24	Wed	16	14, 10	CB6438, C6439
23	2135	983		983		983	400	1500	3	720	24	Thu	17	15, 11, 14	D6437, D6440, CB64
24	1810	1145		1145	2.2	1170	400	1250	2	455	24	Fri	18	16, 13	CB6442, CB6445
25	1820	1124		1124	2.7	1154	400	1313	2	444	24	Sat	19	12, 12	D6434, C6446
26	1927	1141		1141		1141	400	1375	2	467	24	Sun	20	8, 9	C6448, C6450
27	1977	1085		1085		1085	400	1438	2	610	24	Mon	21	11,9,9	D6447,D6449,D6452
28	2252	967		967	3.1	997	400	1500	2	477	24	Tue	22	9, 8	C6453, D6454
29	2302	1041		1041	2.9	1071	400	1375	3	638	24	Wed	23	11, 10, 10	C6451, D6456, D6455
30	2387	1097		1097		1097	400	1125	2	462	24	Thu	24	10, 9	D6458, C6457
31	1999	1141		1141	2.6	1171	400	1063	2	449	24	Fri	25	11, 12	D6460, C6461
32	1724	1051		1051	2.9	1081	400	1250	2	446	24	Sat	26	18, 12	D6462, C6463
33	1774	1200		1200		1200	400	1250	2	418	24	Sun	27	12, 14	D6465, C6464
34	1724	1201		1201		1201	600	1375	2	405	24	Mon	28	14, 15	C6466, D6468
35	1534	1207		1207		1207	400	1500	3	664	24	Tue	29	8, 9, 11	D6469, D6467, C6470
36	1764	1180		1180	1.7	1200	400	1438	3	699	24	Wed	30	10, 7, 6	C6471, D6473, D6472
37	**1789**	**1128**		**1128**	**0.0**	**1128**	**600**	**1313**	**3**	**605**	**24**	**Thu**	**31**	**9, 12, 14**	**C6475, D6476, C**
39	1620							1375.00						17	
40		32595	0	32595	1.2	33000	12800		65	14557.5186	744				
41											0.447				
42		32595	0	32595	1.2	33000	12800		65	14558	744		0.3927		
43											0.447				
47				[illegible]			[illegible]			[illegible]	[illegible]				

STRIP PRODUCTION

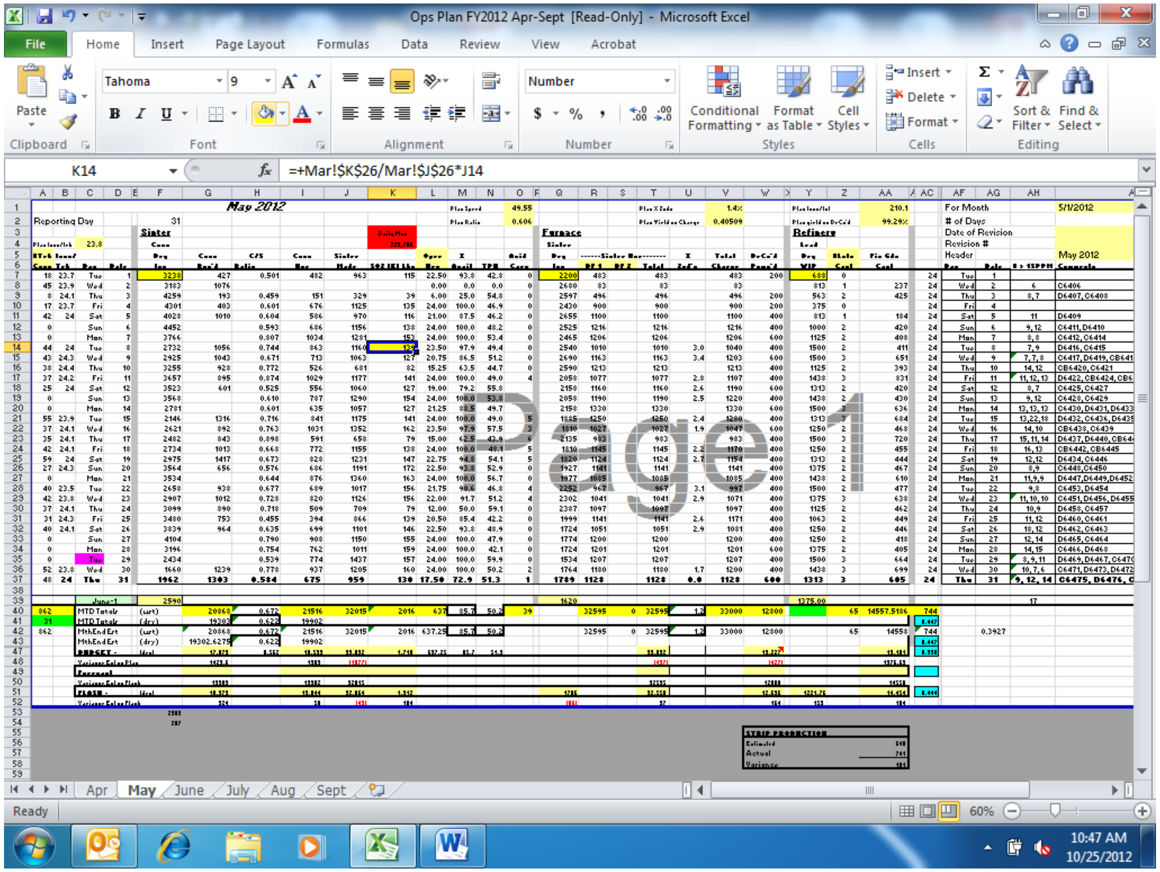
Estimated	[illegible]
Actual	[illegible]
Variance	[illegible]

Page 1

Apr | May | June | July | Aug | Sept

Ready | 60%

10:47 AM 10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K14
=+Mar!$K$26/Mar!$J$26*J14
May 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:47 AM
10/25/2012

Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel

K15 =+Mar!$K$26/Mar!$J$26*J15

May 2012

Reporting Day 31

Plan values: 23.8 | 49.55 | 0.606 | 1.4% | 0.40509 | 210.1 | 99.29%

For Month: 5/1/2012
# of Days
Date of Revision
Revision #
Header: May 2012

Sinter | Furnace | Refinery

Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC	AF	AG	AH	AI
7	18	23.7	Tue	1	3238	427	0.501	482	963	115	22.50	93.8	42.8	0	2200	483		483		483	200	688	0		24	Tue	1		
8	45	23.9	Wed	2	3183	1076					0.00	0.0	0.0	0	2680	83		83		83		813	1	237	24	Wed	2	6	C6406
9	8	24.1	Thu	3	4259	193	0.459	151	329	39	6.00	25.0	54.8	0	2597	496		496		496	200	563	2	425	24	Thu	3	8,7	D6407, C6408
10	17	23.7	Fri	4	4301	403	0.601	676	1125	135	24.00	100.0	46.9	0	2430	900		900		900	200	375	0		24	Fri	4		
11	42	24	Sat	5	4028	1010	0.604	586	970	116	21.00	87.5	46.2	0	2655	1100		1100		1100	400	813	1	184	24	Sat	5	11	D6409
12	0		Sun	6	4452		0.593	686	1156	138	24.00	100.0	48.2	0	2525	1216		1216		1216	400	1000	2	420	24	Sun	6	9,12	C6411, D6410
13	0		Mon	7	3766		0.807	1034	1281	153	24.00	100.0	53.4	0	2465	1206		1206		1206	600	1125	2	408	24	Mon	7	8,8	C6412, C6414
14	44	24	Tue	8	2732	1056	0.744	863	1160	139	23.50	97.9	49.4	0	2540	1010		1010	3.0	1040	400	1500	2	411	24	Tue	8	7,9	D6416, C6415
15	43	24.3	Wed	9	2925	1043	0.671	713	1063	127	20.75	86.5	51.2	0	2690	1163		1163	3.4	1203	600	1500	3	651	24	Wed	9	7,7,8	C6417, D6419, CB641
16	38	24.4	Thu	10	3255	928	0.772	526	681	82	15.25	63.5	44.7	0	2590	1213		1213		1213	400	1125	2	393	24	Thu	10	14,12	CB6420, C6421
17	37	24.2	Fri	11	3657	895	0.874	1029	1177	141	24.00	100.0	49.0	4	2058	1077		1077	2.8	1107	400	1438	3	831	24	Fri	11	11, 12, 13	D6422, CB6424, CB6
18	25	24	Sat	12	3523	601	0.525	556	1060	127	19.00	79.2	55.8	0	2158	1160		1160	2.6	1190	600	1313	2	420	24	Sat	12	8,7	C6425, C6427
19	0		Sun	13	3568		0.610	787	1290	154	24.00	100.0	53.8	0	2058	1190		1190	2.5	1220	400	1438	2	430	24	Sun	13	9,12	C6428, C6429
20	0		Mon	14	2781		0.601	635	1057	127	21.25	88.5	49.7	0	2158	1330		1330		1330	600	1500	3	636	24	Mon	14	13, 13, 13	C6430, D6431, D6433
21	55	23.9	Tue	15	2146	1316	0.716	841	1175	141	24.00	100.0	49.0	5	1885	1250		1250	2.4	1280	400	1313	3	684	24	Tue	15	13,22,18	D6432, C6436, D6435
22	37	24.1	Wed	16	2621	892	0.763	1031	1352	162	23.50	97.9	57.5	3	1810	1027		1027	1.9	1047	600	1250	2	468	24	Wed	16	14,10	CB6438, C6439
23	35	24.1	Thu	17	2482	843	0.898	591	658	79	15.00	62.5	43.9	6	2135	983		983		983	400	1500	3	720	24	Thu	17	15, 11, 14	D6437, C6440, CB64
24	42	24.1	Fri	18	2734	1013	0.668	772	1155	138	24.00	100.0	48.1	5	1810	1145		1145	2.2	1170	400	1250	2	455	24	Fri	18	16, 13	CB6442, CB6445
25	59	24	Sat	19	2975	1417	0.673	828	1231	147	22.75	94.8	54.1	5	1820	1124		1124	2.7	1154	400	1313	2	444	24	Sat	19	12,12	D6434, C6446
26	27	24.3	Sun	20	3564	656	0.576	686	1191	172	22.50	93.8	52.9	0	1927	1141		1141		1141	400	1375	2	467	24	Sun	20	8,9	C6448, C6450
27	0		Mon	21	3534		0.644	876	1360	163	24.00	100.0	56.7	0	1977	1085		1085		1085	400	1438	2	610	24	Mon	21	11,9,9	D6447, D6449, D6452
28	40	23.5	Tue	22	2658	938	0.677	689	1017	156	21.75	90.6	46.8	4	2252	967		967	3.1	997	400	1500	2	477	24	Tue	22	9,8	C6453, D6454
29	42	23.8	Wed	23	2907	1012	0.728	820	1126	156	22.00	91.7	51.2	4	2302	1041		1041	2.9	1071	400	1375	3	638	24	Wed	23	11, 10, 10	C6451, D6456, D6455
30	37	24.1	Thu	24	3099	890	0.718	509	709	79	12.00	50.0	59.1	0	2387	1097		1097		1097	400	1125	2	462	24	Thu	24	10,9	D6458, C6457
31	31	24.3	Fri	25	3480	753	0.455	394	866	139	20.50	85.4	42.2	0	1999	1141		1141	2.6	1171	400	1063	2	449	24	Fri	25	11, 12	D6460, C6461
32	40	24.1	Sat	26	3839	964	0.635	699	1101	146	22.50	93.8	48.9	0	1724	1051		1051	2.9	1081	400	1250	2	446	24	Sat	26	18, 12	D6462, C6463
33	0		Sun	27	4104		0.790	908	1150	155	24.00	100.0	47.9	0	1774	1200		1200		1200	400	1250	2	418	24	Sun	27	12, 14	D6465, C6464
34	0		Mon	28	3196		0.754	762	1011	159	24.00	100.0	42.1	0	1724	1201		1201		1201	600	1375	2	405	24	Mon	28	14, 15	C6466, D6468
35	0		Tue	29	2434		0.539	774	1437	157	24.00	100.0	59.9	0	1534	1207		1207		1207	400	1500	3	664	24	Tue	29	8, 9, 11	D6469, D6467, C6470
36	52	23.8	Wed	30	1660	1239	0.778	937	1205	160	24.00	100.0	50.2	2	1764	1180		1180	1.7	1200	400	1438	3	699	24	Wed	30	10, 7, 6	C6471, D6473, D6472
37	48	24	Thu	31	1962	1303	0.584	675	959	130	17.50	72.9	51.3	1	1789	1128		1128	0.0	1128	600	1313	3	605	24	Thu	31	9, 12, 14	C6475, D6476, C

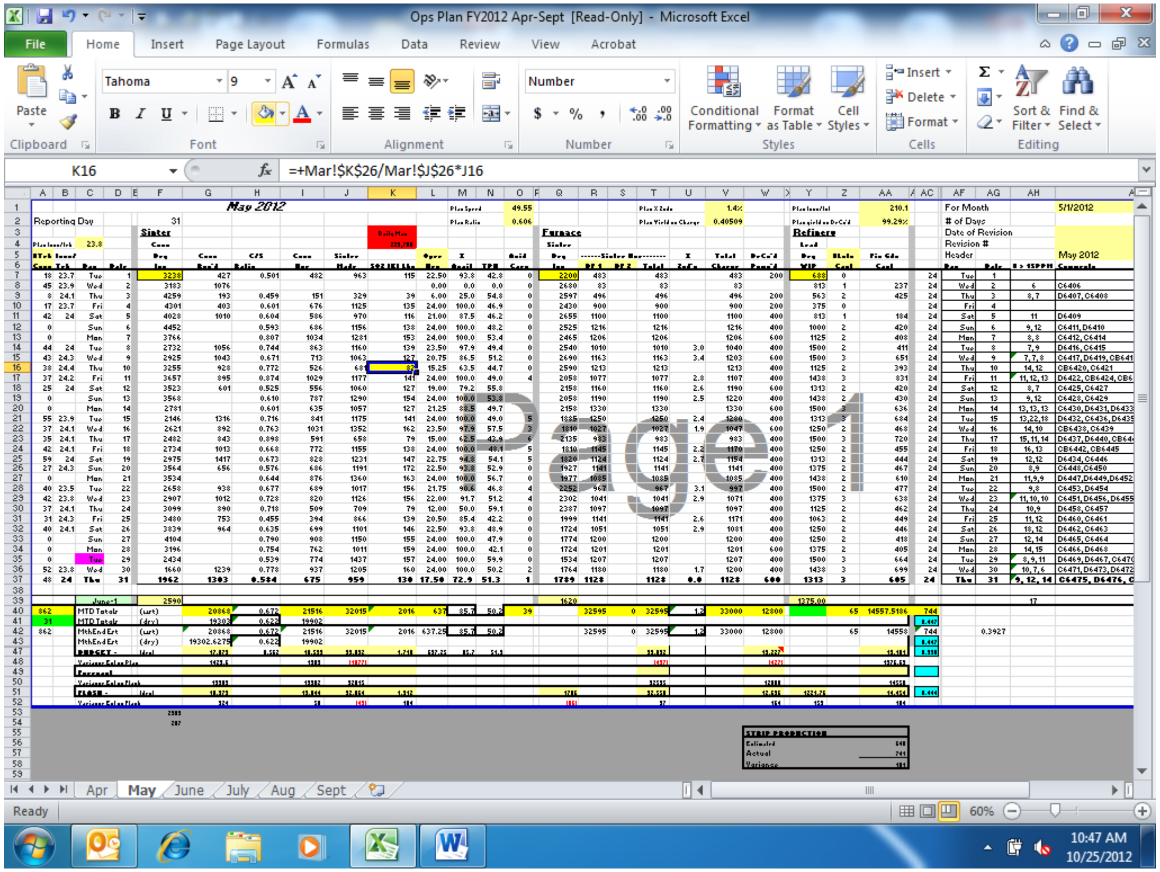
Row	A	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC	AG	AH
39		June-1		2590										1620							1375.00					17
40	862	MTD Totals	(wt)		20868	0.672	21516	32015	2016	637	85.7	50.2	39		32595	0	32595	1.2	33000	12800		65	14557.5186	744		
41	31	MTD Totals	(dry)		19303	0.622	19902																	0.447		
42	862	MthEnd Est	(wt)		20868	0.672	21516	32015	2016	637.25	85.7	50.2			32595	0	32595	1.2	33000	12800		65	14558	744	0.3927	
43		MthEnd Est	(dry)		19302.6275	0.622	19902																	0.447		

STRIP PRODUCTION
Estimated
Actual
Variance

Apr | May | June | July | Aug | Sept

Ready 60%

10:47 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Paste
Tahoma
9
Number
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
K16
=+Mar!$K$26/Mar!$J$26*J16
May 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
MTD Totals
MthEndEst
June-1
Page 1
STRIP PRODUCTION
Estimated
Actual
Variance
Apr
May
June
July
Aug
Sept
Ready
60%
10:47 AM
10/25/2012

Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel

K17 =+Mar!$K$26/Mar!$J$26*J17

May 2012

Reporting Day 31 | Plan Speed 49.55 | Plan Ratio 0.606 | Plan X Zinc 1.4% | Plan Yield on Charge 0.40509 | Plan tons/hr 210.1 | Plan yield on DeCu'd 99.29%

Plan tons/tek 23.8 | Daily Max 229,788

For Month 5/1/2012
# of Days
Date of Revision
Revision #
Header May 2012

Sinter

Row	#Tek Cons	Tons/Tek	Day	Date	Conc Dry Inv	Conc Rec'd	C/S Ratio	Conc Bur	Sinter Made	SO2 (K) lbs	Oper Hrs	% Avail	TPH	Acid Cons
7	18	23.7	Tue	1	3238	427	0.501	482	963	115	22.50	93.8	42.8	0
8	45	23.9	Wed	2	3183	1076					0.00	0.0	0.0	0
9	8	24.1	Thu	3	4259	193	0.459	151	329	39	6.00	25.0	54.8	0
10	17	23.7	Fri	4	4301	403	0.601	676	1125	135	24.00	100.0	46.9	0
11	42	24	Sat	5	4028	1010	0.604	586	970	116	21.00	87.5	46.2	0
12	0		Sun	6	4452		0.593	686	1156	138	24.00	100.0	48.2	0
13	0		Mon	7	3766		0.807	1034	1281	153	24.00	100.0	53.4	0
14	44	24	Tue	8	2732	1056	0.744	863	1160	139	23.50	97.9	49.4	0
15	43	24.3	Wed	9	2925	1043	0.671	713	1063	127	20.75	86.5	51.2	0
16	38	24.4	Thu	10	3255	928	0.772	526	681	82	15.25	63.5	44.7	0
17	37	24.2	Fri	11	3657	895	0.874	1029	1177	141	24.00	100.0	49.0	4
18	25	24	Sat	12	3523	601	0.525	556	1060	127	19.00	79.2	55.8	
19	0		Sun	13	3568		0.610	787	1290	154	24.00	100.0	53.8	
20	0		Mon	14	2781		0.601	635	1057	127	21.25	88.5	49.7	
21	55	23.9	Tue	15	2146	1316	0.716	841	1175	141	24.00	100.0	49.0	5
22	37	24.1	Wed	16	2621	892	0.763	1031	1352	162	23.50	97.9	57.5	3
23	35	24.1	Thu	17	2482	843	0.898	591	658	79	15.00	62.5	43.9	6
24	42	24.1	Fri	18	2734	1013	0.668	772	1155	138	24.00	100.0	48.1	5
25	59	24	Sat	19	2975	1417	0.673	828	1231	147	22.75	94.8	54.1	5
26	27	24.3	Sun	20	3564	656	0.576	686	1191	172	22.50	93.8	52.9	0
27	0		Mon	21	3534		0.644	876	1360	163	24.00	100.0	56.7	0
28	40	23.5	Tue	22	2658	938	0.677	689	1017	156	21.75	90.6	46.8	4
29	42	23.8	Wed	23	2907	1012	0.728	820	1126	156	22.00	91.7	51.2	4
30	37	24.1	Thu	24	3099	890	0.718	509	709	79	12.00	50.0	59.1	0
31	31	24.3	Fri	25	3480	753	0.455	394	866	139	20.50	85.4	42.2	0
32	40	24.1	Sat	26	3839	964	0.635	699	1101	146	22.50	93.8	48.9	0
33	0		Sun	27	4104		0.790	908	1150	155	24.00	100.0	47.9	0
34	0		Mon	28	3196		0.754	762	1011	159	24.00	100.0	42.1	0
35	0		Tue	29	2434		0.539	774	1437	157	24.00	100.0	59.9	0
36	52	23.8	Wed	30	1660	1239	0.778	937	1205	160	24.00	100.0	50.2	2
37	48	24	Thu	31	1962	1303	0.584	675	959	130	17.50	72.9	51.3	1
39			June-1		2590									
40	862		MTD Totals		(wt)	20868	0.672	21516	32015	2016	637	85.7	50.2	39
41	31		MTD Totals		(dry)	19303	0.622	19902						
42	862		MthEnd Est		(wt)	20868	0.672	21516	32015	2016	637.25	85.7	50.2	
43			MthEnd Est		(dry)	19302.6275	0.622	19902						
47			PRESET -		Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	637.25	85.7	51.3	
48			Variance Est vs Plan			[illegible]		[illegible]	[illegible]					
49			Forecast											
50			Variance Est vs Flash			[illegible]		[illegible]	[illegible]					
51			FLASH -		Ideal	[illegible]		[illegible]	[illegible]	[illegible]				
52			Variance Est vs Flash			[illegible]		[illegible]	[illegible]	[illegible]				

Furnace / **Refinery**

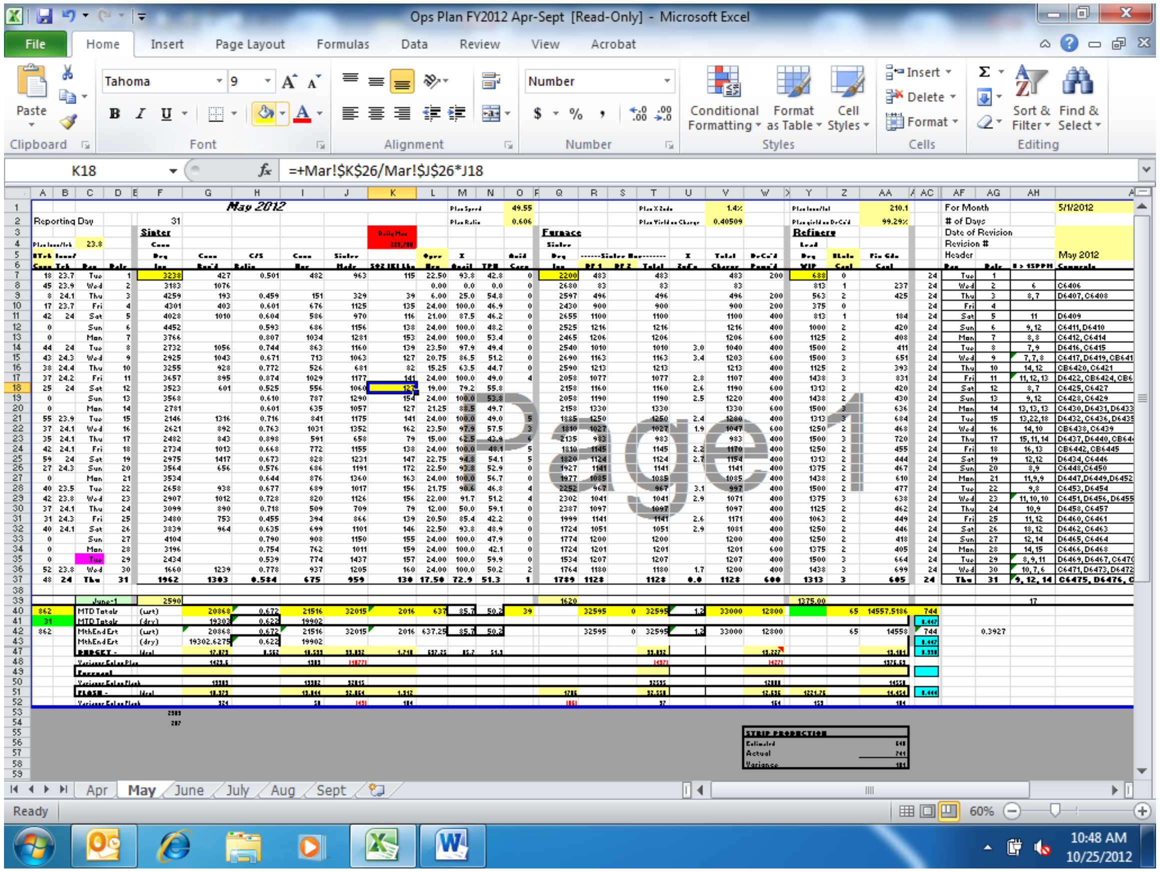
Row	Sinter Dry Inv	Sinter Bur BF 1	Sinter Bur BF 2	Sinter Bur Total	% ZnCu	Total Charge	DeCu'd Pump'd	Lead Dry WIP	Blade Cast	Fin Gds Cast	AC	Day	Date	# > 15PPM	Comments
7	2200	483		483		483	200	688	0		24	Tue	1		
8	2680	83		83		83		813	1	237	24	Wed	2	6	C6406
9	2597	496		496		496	200	563	2	425	24	Thu	3	8,7	D6407, C6408
10	2430	900		900		900	200	375	0		24	Fri	4		
11	2655	1100		1100		1100	400	813	1	184	24	Sat	5	11	D6409
12	2525	1216		1216		1216	400	1000	2	420	24	Sun	6	9,12	C6411, D6410
13	2465	1206		1206		1206	600	1125	2	408	24	Mon	7	8,8	C6412, C6414
14	2540	1010		1010	3.0	1040	400	1500	2	411	24	Tue	8	7,9	D6416, C6415
15	2690	1163		1163	3.4	1203	600	1500	3	651	24	Wed	9	7,7,8	C6417, D6419, CB641
16	2590	1213		1213		1213	400	1125	2	393	24	Thu	10	14,12	CB6420, C6421
17	2058	1077		1077	2.8	1107	400	1438	3	831	24	Fri	11	11,12,13	D6422, CB6424, CB6
18	2158	1160		1160	2.6	1190	600	1313	2	420	24	Sat	12	8,7	C6425, C6427
19	2058	1190		1190	2.5	1220	400	1438	2	430	24	Sun	13	9,12	C6428, C6429
20	2158	1330		1330		1330	600	1500	3	636	24	Mon	14	13,13,13	C6430, D6431, D6433
21	1885	1250		1250	2.4	1280	400	1313	3	684	24	Tue	15	13,22,18	D6432, C6436, D6435
22	1810	1027		1027	1.9	1047	600	1250	2	468	24	Wed	16	14,10	CB6438, C6439
23	2135	983		983		983	400	1500	3	720	24	Thu	17	15,11,14	D6437, D6440, CB64
24	1810	1145		1145	2.2	1170	400	1250	2	455	24	Fri	18	16,13	CB6442, CB6445
25	1820	1124		1124	2.7	1154	400	1313	2	444	24	Sat	19	12,12	D6434, C6446
26	1927	1141		1141		1141	400	1375	2	467	24	Sun	20	8,9	C6448,C6450
27	1977	1085		1085		1085	400	1438	2	610	24	Mon	21	11,9,9	D6447,D6449,D6452
28	2252	967		967	3.1	997	400	1500	2	477	24	Tue	22	9,8	C6453, D6454
29	2302	1041		1041	2.9	1071	400	1375	3	638	24	Wed	23	11,10,10	C6451, D6456, D6455
30	2387	1097		1097		1097	400	1125	2	462	24	Thu	24	10,9	D6458, C6457
31	1999	1141		1141	2.6	1171	400	1063	2	449	24	Fri	25	11,12	D6460, C6461
32	1724	1051		1051	2.9	1081	400	1250	2	446	24	Sat	26	18,12	D6462, C6463
33	1774	1200		1200		1200	400	1250	2	418	24	Sun	27	12,14	D6465, C6464
34	1724	1201		1201		1201	600	1375	2	405	24	Mon	28	14,15	C6466, D6468
35	1534	1207		1207		1207	400	1500	3	664	24	Tue	29	8,9,11	D6469, D6467, C6470
36	1764	1180		1180	1.7	1200	400	1438	3	699	24	Wed	30	10,7,6	C6471, D6473, D6472
37	1789	1128		1128	0.0	1128	600	1313	3	605	24	Thu	31	9, 12, 14	C6475, D6476, C
39	1620							1375.00						17	
40		32595	0	32595	1.2	33000	12800		65	14557.5186	744				
41											0.447				
42		32595	0	32595	1.2	33000	12800		65	14558	744		0.3927		
43											0.447				
47				[illegible]			[illegible]			[illegible]	0.338				
48				[illegible]			[illegible]			[illegible]					
51	1788			[illegible]			[illegible]	[illegible]		[illegible]	0.444				

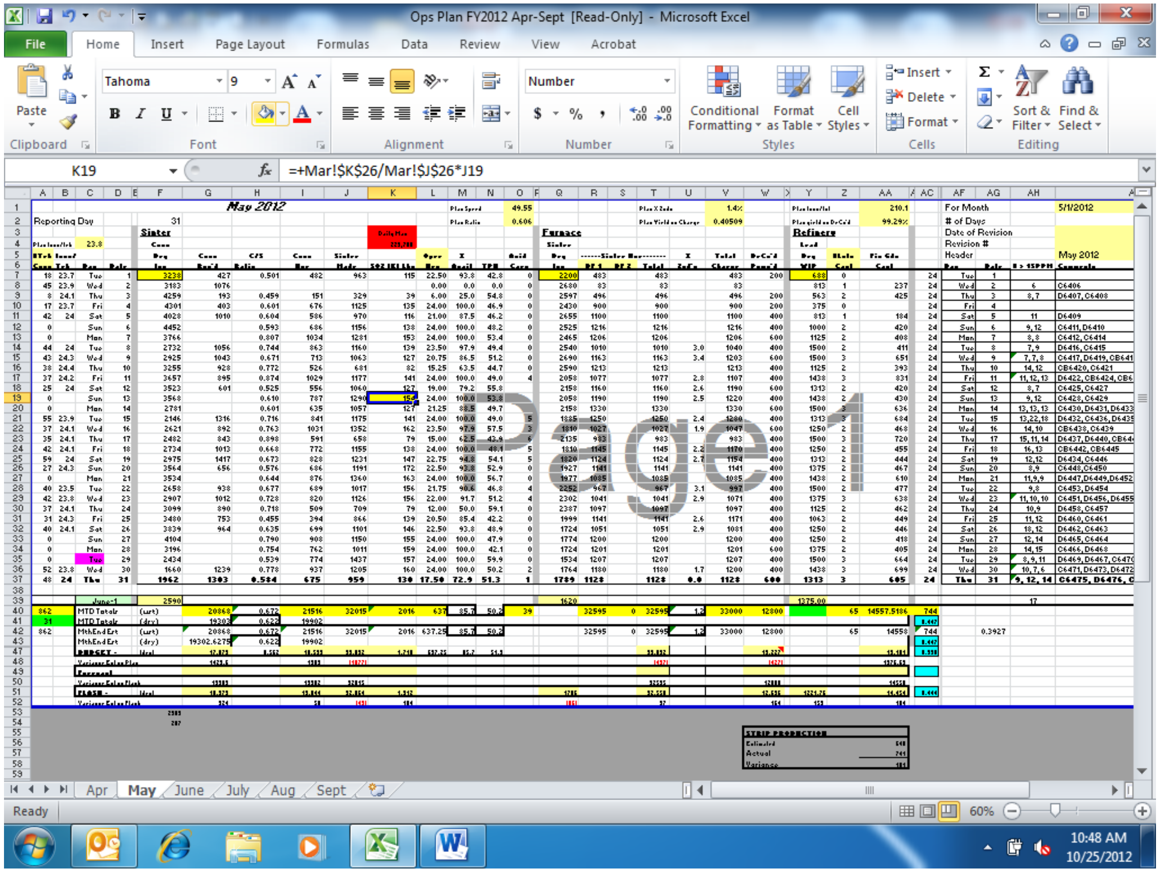
STRIP PRODUCTION	
Estimated	[illegible]
Actual	[illegible]
Variance	[illegible]

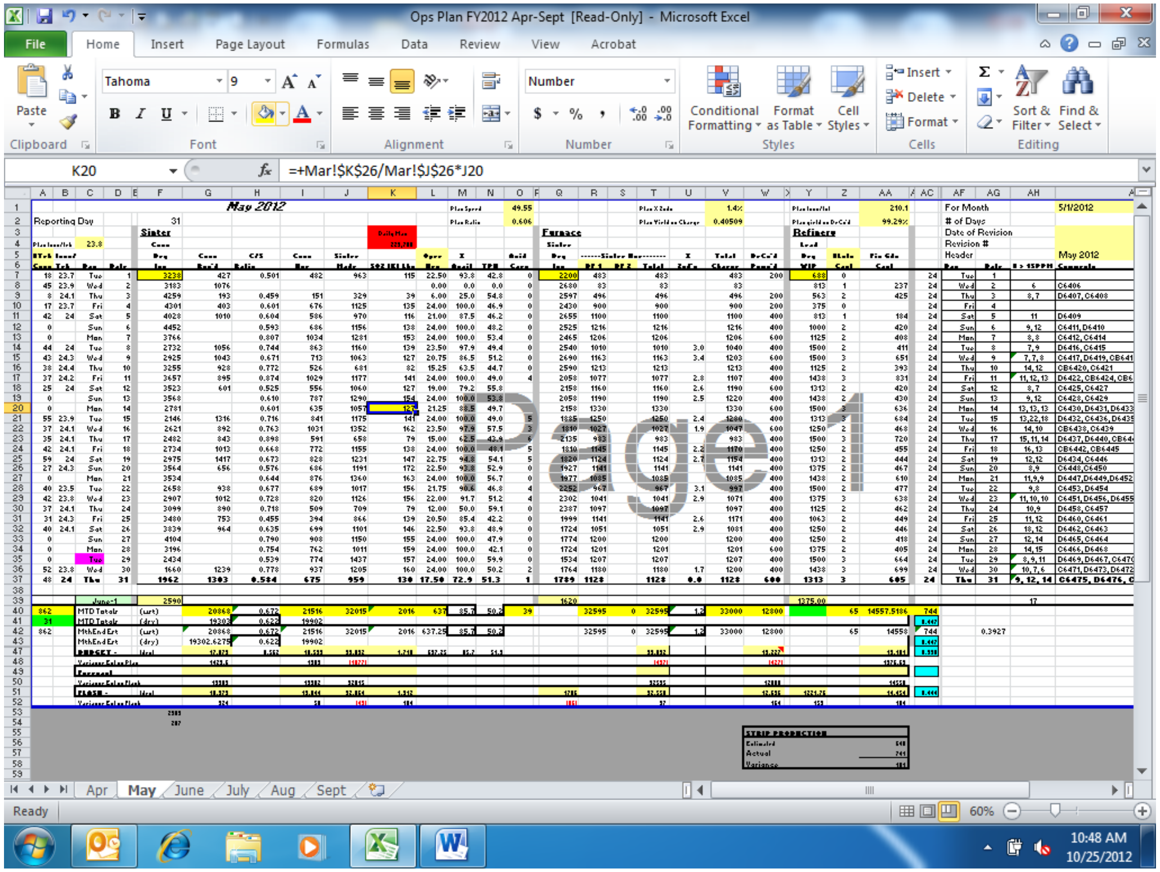
Apr | May | June | July | Aug | Sept

Ready 60%

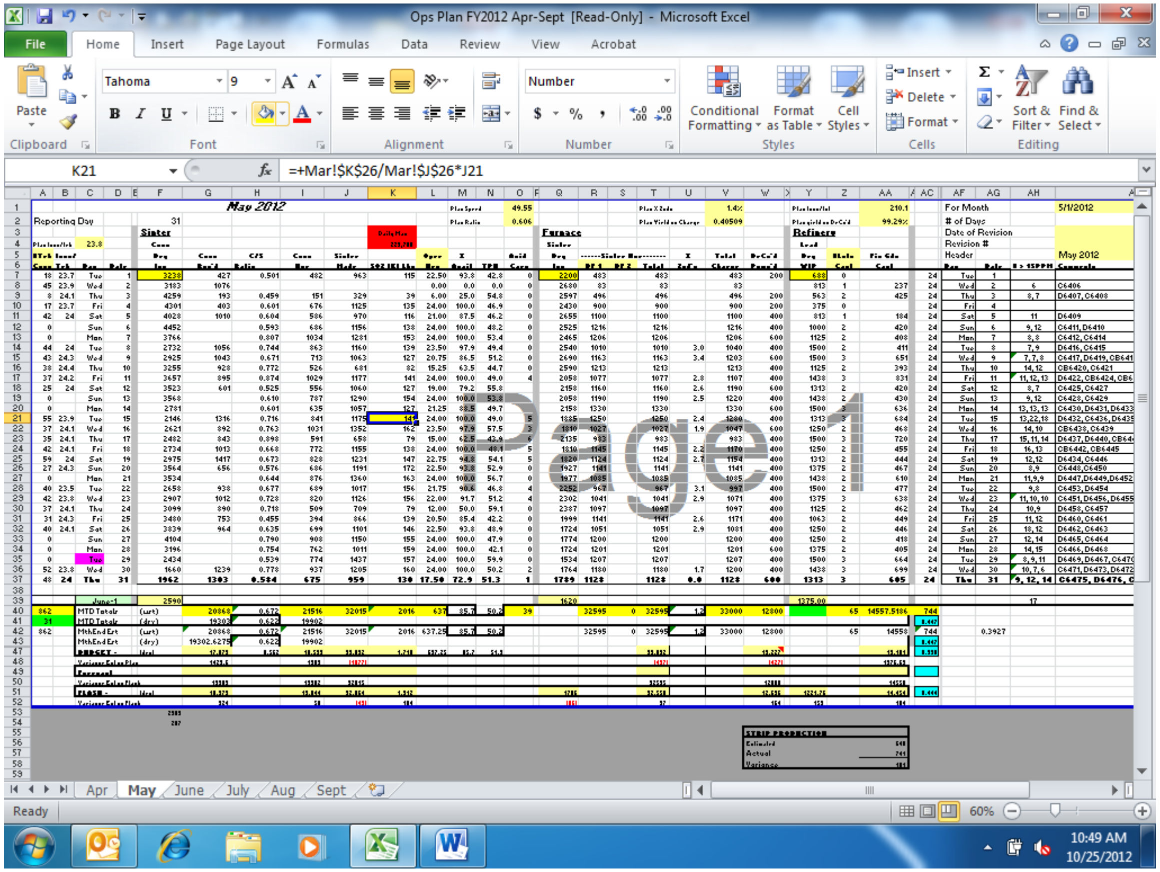
10:48 AM 10/25/2012

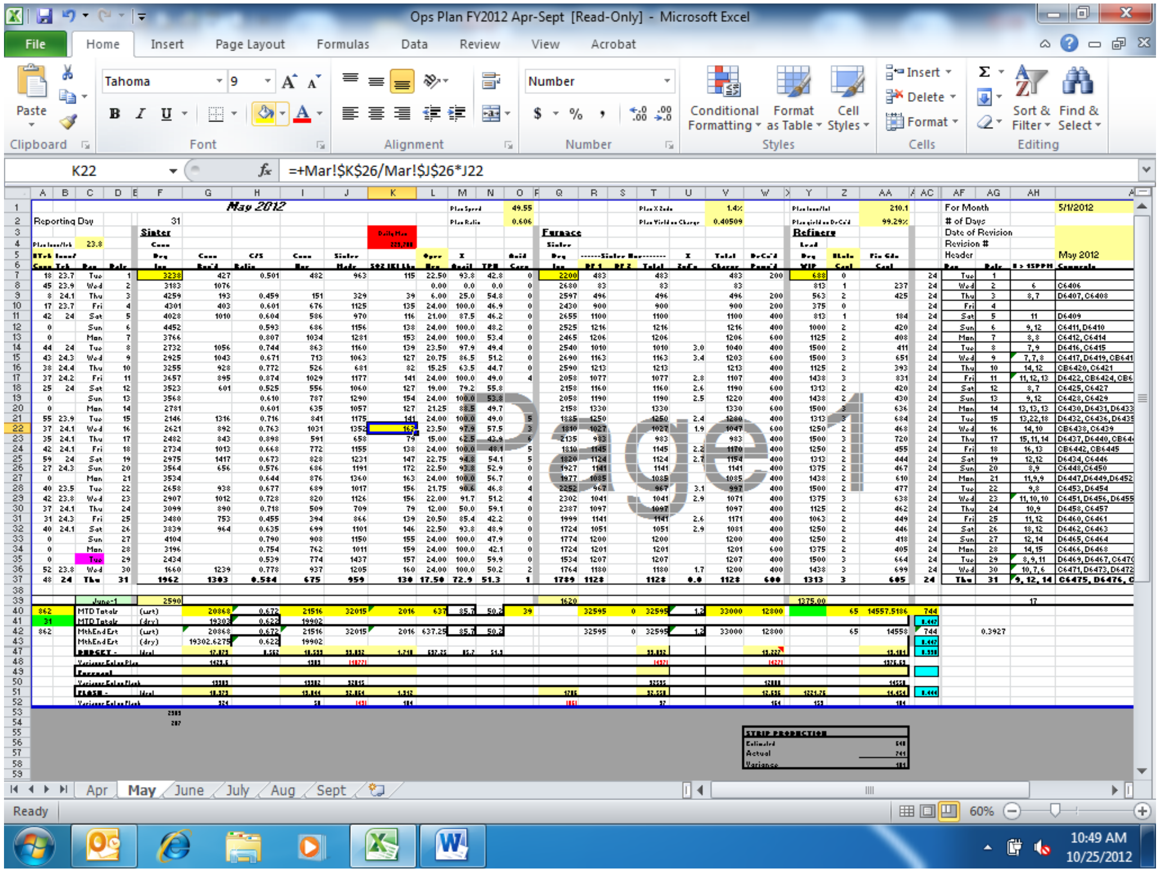

Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K18
=+Mar!$K$26/Mar!$J$26*J18
May 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
STRIP PRODUCTION
Estimated
Actual
Variance
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:48 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Tahoma
9
Number
Paste
Clipboard
Font
Alignment
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
K19
=+Mar!$K$26/Mar!$J$26*J19
May 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page1
STRIP PRODUCTION
Estimated
Actual
Variance
Apr
May
June
July
Aug
Sept
Ready
60%
10:48 AM
10/25/2012

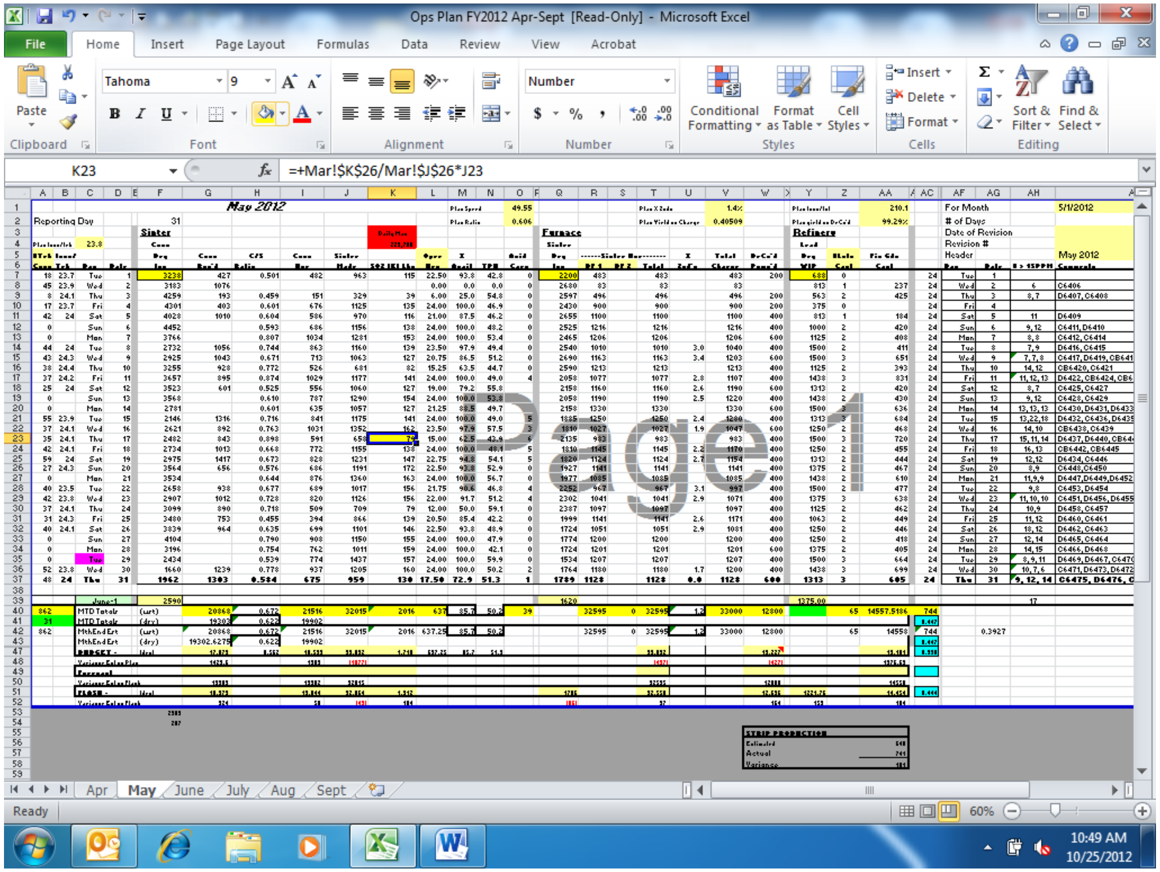


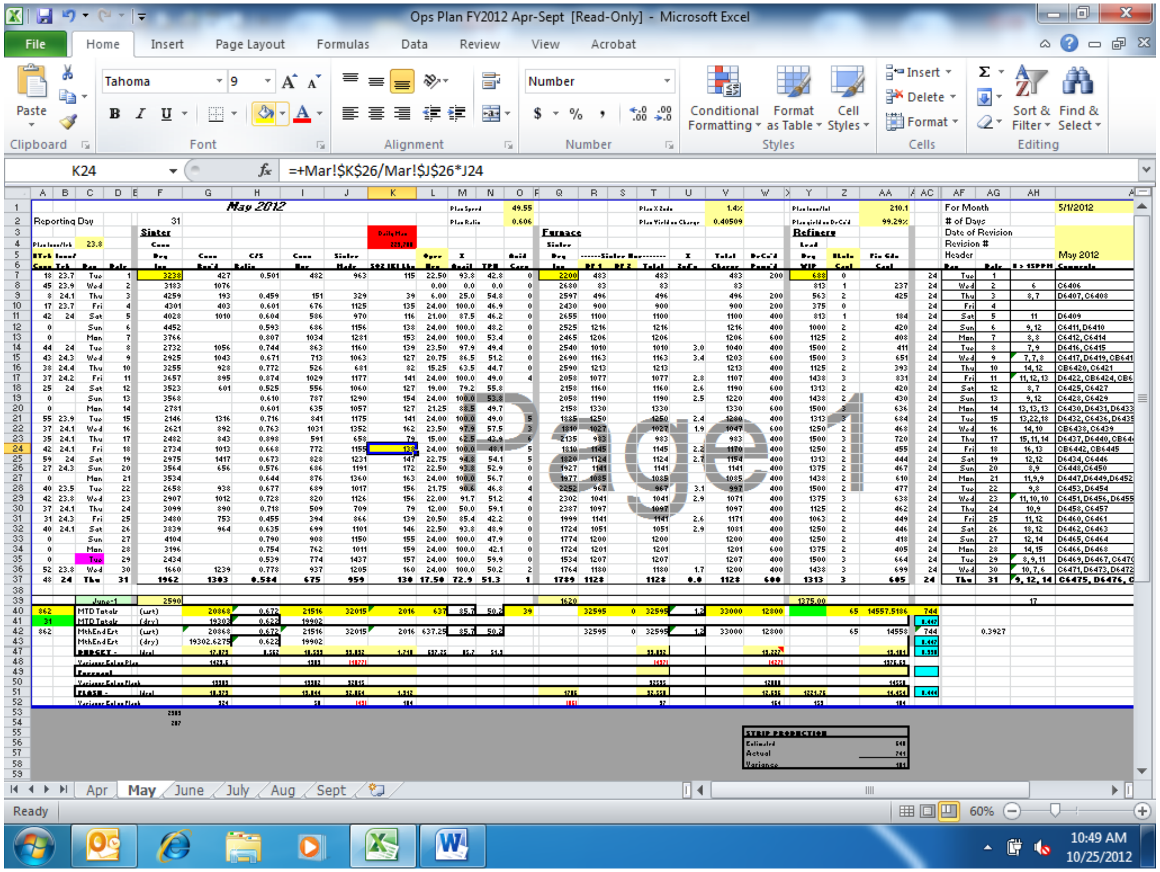
Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Paste
Clipboard
Tahoma
9
Font
Alignment
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
K20
=+Mar!$K$26/Mar!$J$26*J20
May 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
MTD Totals
MthEndEst
STRIP PRODUCTION
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:48 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K21
=+Mar!$K$26/Mar!$J$26*J21
May 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
MTD Totals
MthEnd Est
STRIP PRODUCTION
Estimated
Actual
Variance
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:49 AM
10/25/2012

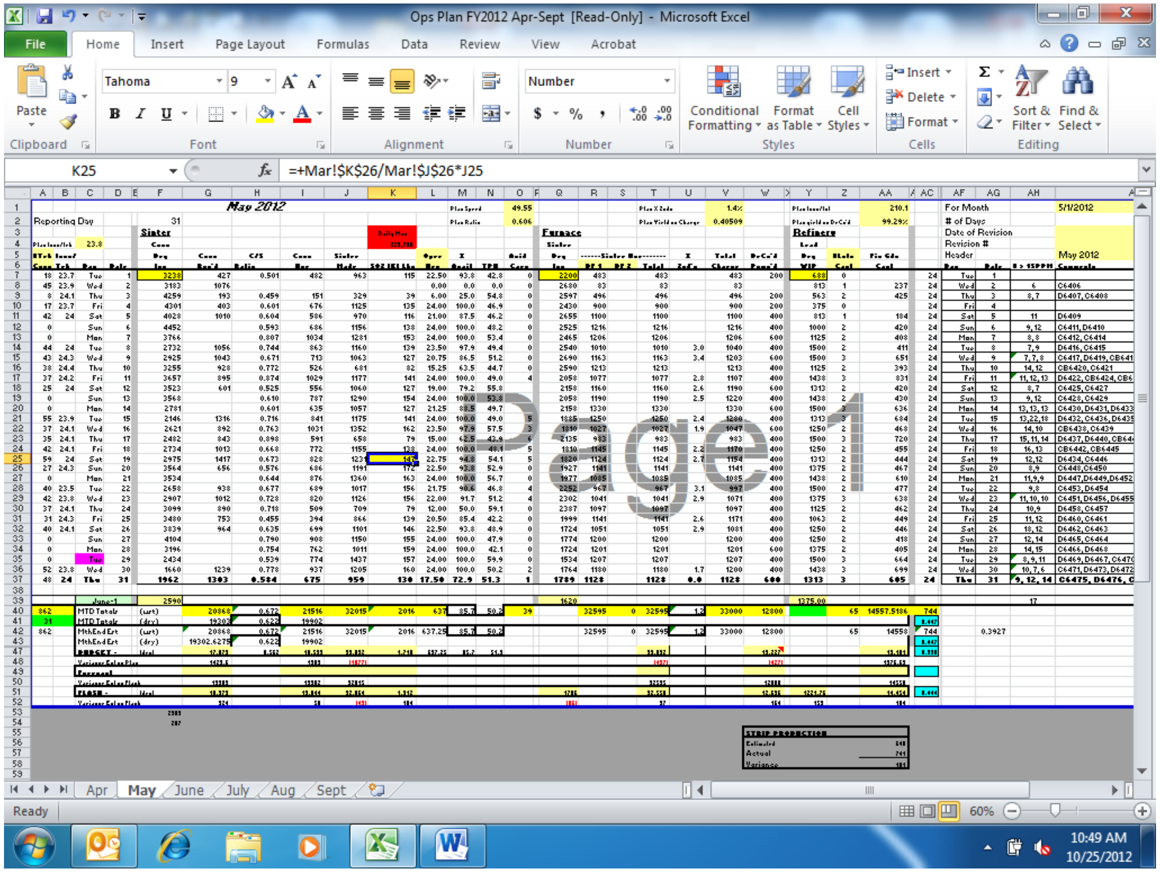


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Paste
Clipboard
Tahoma
9
Font
Alignment
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
K22
=+Mar!$K$26/Mar!$J$26*J22
May 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:49 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K23
=+Mar!$K$26/Mar!$J$26*J23
May 2012
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:49 AM
10/25/2012



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K24
=+Mar!$K$26/Mar!$J$26*J24
May 2012
Reporting Day
31
Sinter
Daily Max
Plan Speed
49.55
Plan Ratio
0.606
Furnace
Plan X Zndo
1.4%
Plan Yield on Charge
0.40509
Refinery
210.1
99.29%
For Month
5/1/2012
# of Days
Date of Revision
Revision #
Header
May 2012
MTD Totals
STRIP PRODUCTION
Estimated
Actual
Variance
Apr
May
June
July
Aug
Sept
Ready
60%
10:49 AM
10/25/2012



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel

K25 =+Mar!$K$26/Mar!$J$26*J25

Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC	AF	AG	AH	
1							May 2012					Plan Speed		49.55						1.4%				210.1		For Month			5/1/2012
2	Reporting Day				31							Plan Ratio		0.606				Plan Yield on Charge		0.40509				99.29%		# of Days			
3					Sinter										Furnace							Refinery				Date of Revision			
4			23.8		Conc										Sinter							Lead				Revision #			
5																										Header			May 2012
7	18	23.7	Tue	1	3238	427	0.501	482	963	115	22.50	93.8	42.8	0	2200	483		483		483	200	688	0		24	Tue	1		
8	45	23.9	Wed	2	3183	1076					0.00	0.0	0.0	0	2680	83		83		83		813	1	237	24	Wed	2	6	C6406
9	8	24.1	Thu	3	4259	193	0.459	151	329	39	6.00	25.0	54.8	0	2597	496		496		496	200	563	2	425	24	Thu	3	8, 7	D6407, C6408
10	17	23.7	Fri	4	4301	403	0.601	676	1125	135	24.00	100.0	46.9	0	2430	900		900		900	200	375	0		24	Fri	4		
11	42	24	Sat	5	4028	1010	0.604	586	970	116	21.00	87.5	46.2	0	2655	1100		1100		1100	400	813	1	184	24	Sat	5	11	D6409
12	0		Sun	6	4452		0.593	686	1156	138	24.00	100.0	48.2	0	2525	1216		1216		1216	400	1000	2	420	24	Sun	6	9, 12	C6411, D6410
13	0		Mon	7	3766		0.807	1034	1281	153	24.00	100.0	53.4	0	2465	1206		1206		1206	600	1125	2	408	24	Mon	7	8, 8	C6412, C6414
14	44	24	Tue	8	2732	1056	0.744	863	1160	139	23.50	97.9	49.4	0	2540	1010		1010	3.0	1040	400	1500	2	411	24	Tue	8	7, 9	D6416, C6415
15	43	24.3	Wed	9	2925	1043	0.671	713	1063	127	20.75	86.5	51.2	0	2690	1163		1163	3.4	1203	600	1500	3	651	24	Wed	9	7, 7, 8	C6417, D6419, CB641
16	38	24.4	Thu	10	3255	928	0.772	526	681	82	15.25	63.5	44.7	0	2590	1213		1213		1213	400	1125	2	393	24	Thu	10	14, 12	CB6420, C6421
17	37	24.2	Fri	11	3657	895	0.874	1029	1177	141	24.00	100.0	49.0	4	2058	1077		1077	2.8	1107	400	1438	3	831	24	Fri	11	11, 12, 13	D6422, CB6424, CB6
18	25	24	Sat	12	3523	601	0.525	556	1060	127	19.00	79.2	55.8		2158	1160		1160	2.6	1190	600	1313	2	420	24	Sat	12	8, 7	C6425, C6427
19	0		Sun	13	3568		0.610	787	1290	154	24.00	100.0	53.8		2058	1190		1190	2.5	1220	400	1438	2	430	24	Sun	13	9, 12	C6428, C6429
20	0		Mon	14	2781		0.601	635	1057	127	21.25	88.5	49.7		2158	1330		1330		1330	600	1500	3	636	24	Mon	14	13, 13, 13	C6430, D6431, D6433
21	55	23.9	Tue	15	2146	1316	0.716	841	1175	141	24.00	100.0	49.0	5	1885	1250		1250	2.4	1280	400	1313	3	684	24	Tue	15	13,22,18	D6432, C6436, D6435
22	37	24.1	Wed	16	2621	892	0.763	1031	1352	162	23.50	97.9	57.5	3	1810	1027		1027	1.9	1047	600	1250	2	468	24	Wed	16	14, 10	CB6438, C6439
23	35	24.1	Thu	17	2482	843	0.898	591	658	79	15.00	62.5	43.9	6	2135	983		983		983	400	1500	3	720	24	Thu	17	15, 11, 14	D6437, D6440, CB64
24	42	24.1	Fri	18	2734	1013	0.668	772	1155	138	24.00	100.0	48.1	5	1810	1145		1145	2.2	1170	400	1250	2	455	24	Fri	18	16, 13	CB6442, CB6445
25	59	24	Sat	19	2975	1417	0.673	828	1231	147	22.75	94.8	54.1	5	1820	1124		1124	2.7	1154	400	1313	2	444	24	Sat	19	12,12	D6434, C6446
26	27	24.3	Sun	20	3564	656	0.576	686	1191	172	22.50	93.8	52.9	0	1927	1141		1141		1141	400	1375	2	467	24	Sun	20	8,9	C6448,C6450
27	0		Mon	21	3534		0.644	876	1360	163	24.00	100.0	56.7	0	1977	1085		1085		1085	400	1438	2	610	24	Mon	21	11,9,9	D6447,D6449,D6452
28	40	23.5	Tue	22	2658	938	0.677	689	1017	156	21.75	90.6	46.8	4	2252	967		967	3.1	997	400	1500	2	477	24	Tue	22	9,8	C6453, D6454
29	42	23.8	Wed	23	2907	1012	0.728	820	1126	156	22.00	91.7	51.2	4	2302	1041		1041	2.9	1071	400	1375	3	638	24	Wed	23	11, 10, 10	C6451, D6456, D6455
30	37	24.1	Thu	24	3099	890	0.718	509	709	79	12.00	50.0	59.1	0	2387	1097		1097		1097	400	1125	2	462	24	Thu	24	10,9	D6458, C6457
31	31	24.3	Fri	25	3480	753	0.455	394	866	139	20.50	85.4	42.2	0	1999	1141		1141	2.6	1171	400	1063	2	449	24	Fri	25	11, 12	D6460, C6461
32	40	24.1	Sat	26	3839	964	0.635	699	1101	146	22.50	93.8	48.9	0	1724	1051		1051	2.9	1081	400	1250	2	446	24	Sat	26	18, 12	D6462, C6463
33	0		Sun	27	4104		0.790	908	1150	155	24.00	100.0	47.9	0	1774	1200		1200		1200	400	1250	2	418	24	Sun	27	12, 14	D6465, C6464
34	0		Mon	28	3196		0.754	762	1011	159	24.00	100.0	42.1	0	1724	1201		1201		1201	600	1375	2	405	24	Mon	28	14, 15	C6466, D6468
35	0		Tue	29	2434		0.539	774	1437	157	24.00	100.0	59.9	0	1534	1207		1207		1207	400	1500	3	664	24	Tue	29	8, 9, 11	D6469, D6467, C6470
36	52	23.8	Wed	30	1660	1239	0.778	937	1205	160	24.00	100.0	50.2	2	1764	1180		1180	1.7	1200	400	1438	3	699	24	Wed	30	10, 7, 6	C6471, D6473, D6472
37	48	24	Thu	31	1962	1303	0.584	675	959	130	17.50	72.9	51.3	1	1789	1128		1128	0.0	1128	600	1313	3	605	24	Thu	31	9, 12, 14	C6475, D6476, C
39			June-1		2590										1620							1375.00						17	
40	862		MTD Totals		(wet)	20868	0.672	21516	32015	2016	637	85.7	50.2	39		32595	0	32595	1.2	33000	12800		65	14557.5186	744				
41	31		MTD Totals		(dry)	19303	0.622	19902																	0.447				
42	862		MthEnd Est		(wet)	20868	0.672	21516	32015	2016	637.25	85.7	50.2			32595	0	32595	1.2	33000	12800		65	14558	744		0.3927		
43			MthEnd Est		(dry)	19302.6275	0.622	19902																	0.447				

STRIP PRODUCTION

Estimated

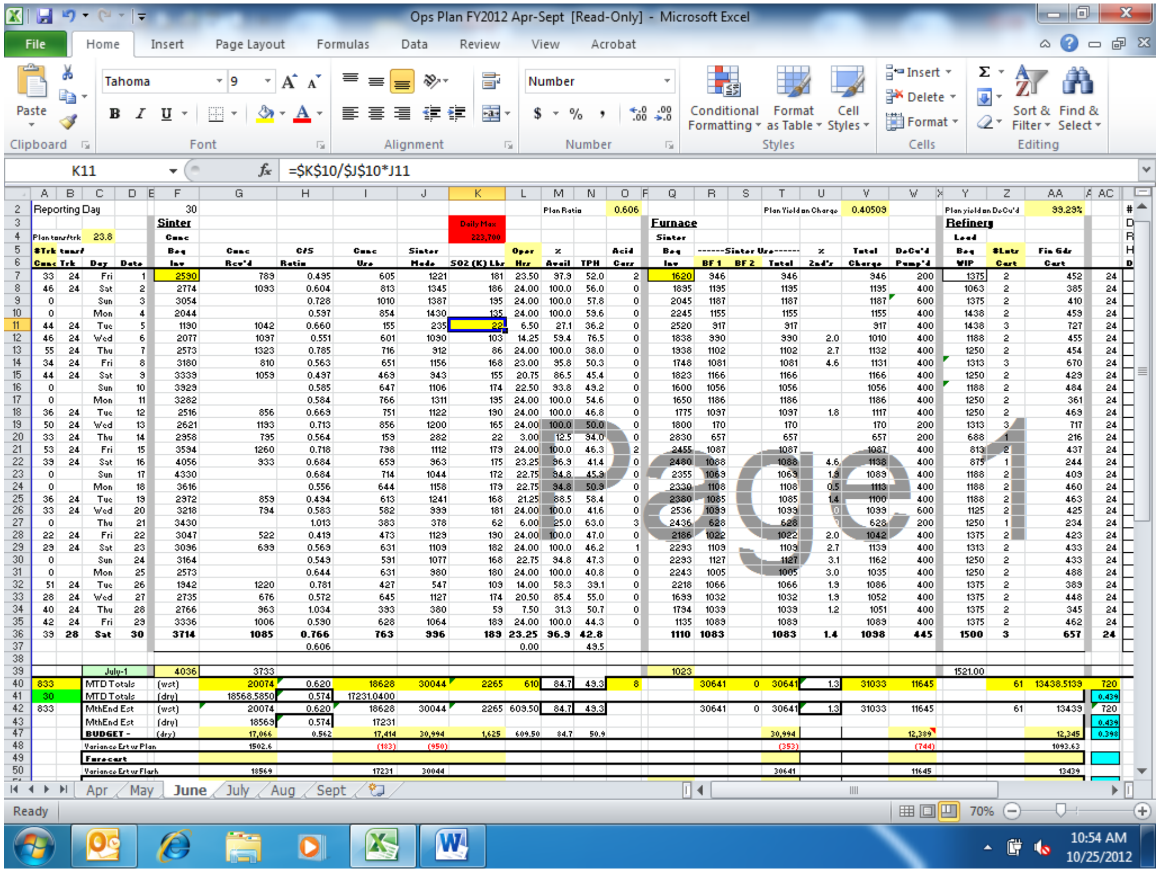
Actual

Variance

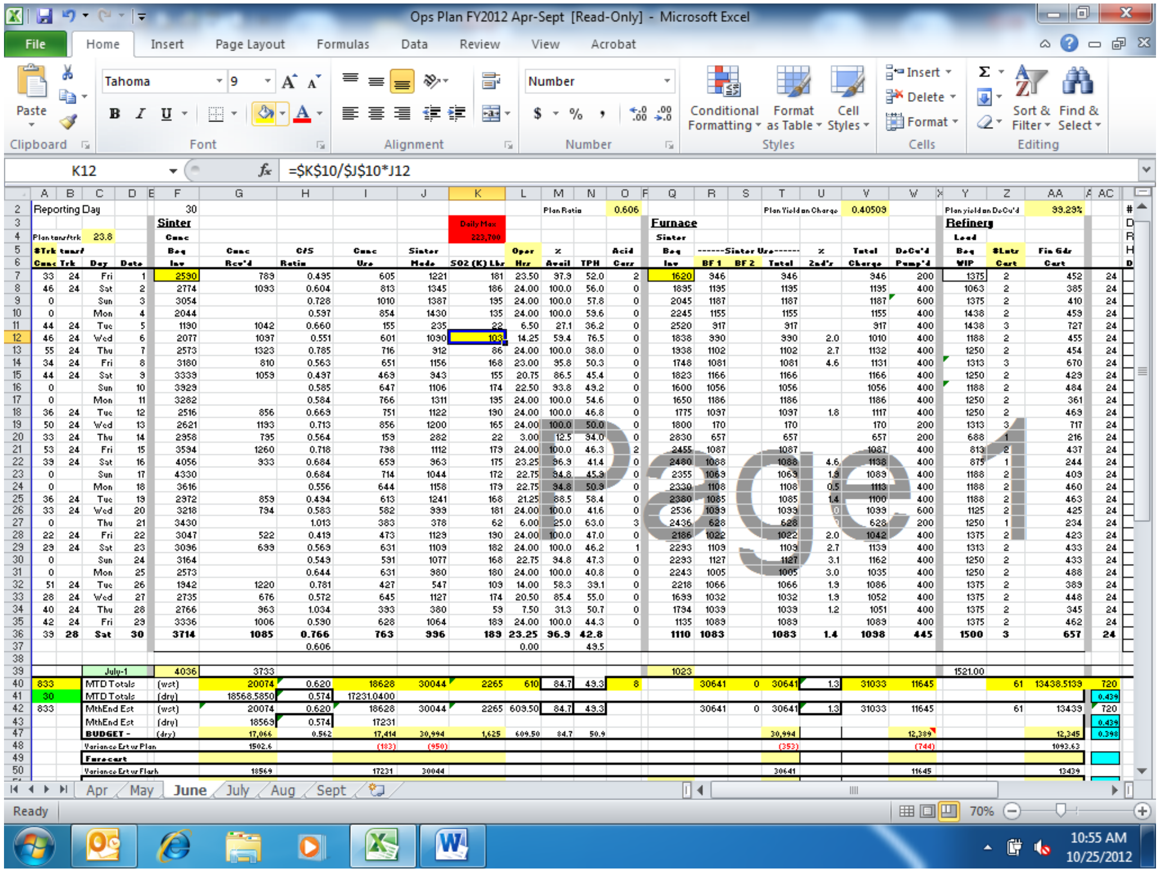
Apr | May | June | July | Aug | Sept

Ready 60%

10:49 AM 10/25/2012

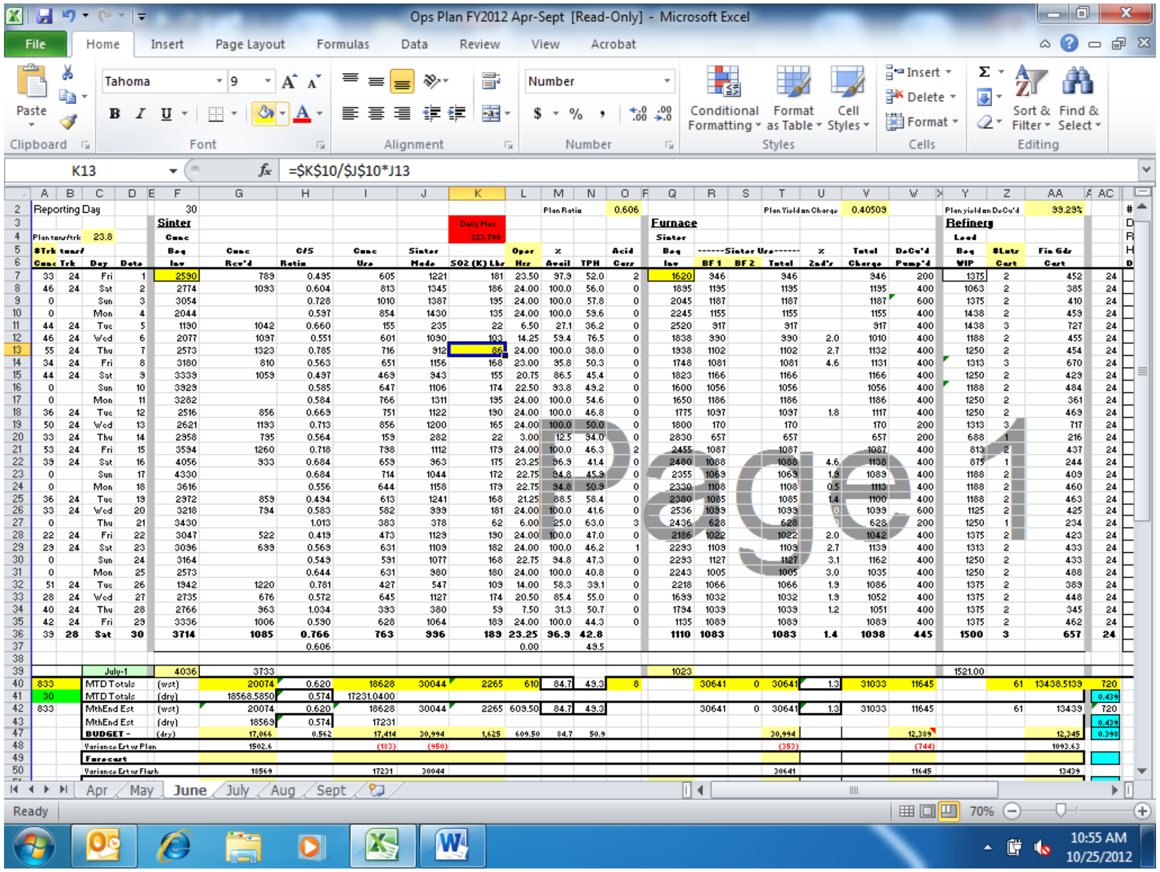


	A	B	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC
2	Reporting Day				30							Plan Ratio		0.606				Plan Yield on Charge		0.40509		Plan yield on DeCu'd		99.29%	
3					Sinter					Daily Max					Furnace							Refinery			
4	Plan tons/trk		23.8		Conc					223,700					Sinter							Lead			
5	#Trk	tons/			Beg	Conc	C/S	Conc	Sinter		Oper	%		Acid	Beg	------Sinter Use------			%	Total	DeCu'd	Beg	#Lots	Fin Gds	
6	Conc	Trk	Day	Date	Inv	Rcv'd	Ratio	Use	Made	SO2 (K) Lbs	Hrs	Avail	TPH	Conv	Inv	BF 1	BF 2	Total	2nd's	Charge	Pump'd	WIP	Cast	Cast	
7	33	24	Fri	1	2590	789	0.495	605	1221	181	23.50	97.9	52.0	2	1620	946		946		946	200	1375	2	452	24
8	46	24	Sat	2	2774	1093	0.604	813	1345	186	24.00	100.0	56.0	0	1895	1195		1195		1195	400	1063	2	385	24
9	0		Sun	3	3054		0.728	1010	1387	195	24.00	100.0	57.8	0	2045	1187		1187		1187	600	1375	2	410	24
10	0		Mon	4	2044		0.597	854	1430	135	24.00	100.0	59.6	0	2245	1155		1155		1155	400	1438	2	459	24
11	44	24	Tue	5	1190	1042	0.660	155	235	22	6.50	27.1	36.2	0	2520	917		917		917	400	1438	3	727	24
12	46	24	Wed	6	2077	1097	0.551	601	1090	103	14.25	59.4	76.5	0	1838	990		990	2.0	1010	400	1188	2	455	24
13	55	24	Thu	7	2573	1323	0.785	716	912	86	24.00	100.0	38.0	0	1938	1102		1102	2.7	1132	400	1250	2	454	24
14	34	24	Fri	8	3180	810	0.563	651	1156	168	23.00	95.8	50.3	0	1748	1081		1081	4.6	1131	400	1313	3	670	24
15	44	24	Sat	9	3339	1059	0.497	469	943	155	20.75	86.5	45.4	0	1823	1166		1166		1166	400	1250	2	429	24
16	0		Sun	10	3929		0.585	647	1106	174	22.50	93.8	49.2	0	1600	1056		1056		1056	400	1188	2	484	24
17	0		Mon	11	3282		0.584	766	1311	195	24.00	100.0	54.6	0	1650	1186		1186		1186	400	1250	2	361	24
18	36	24	Tue	12	2516	856	0.669	751	1122	190	24.00	100.0	46.8	0	1775	1097		1097	1.8	1117	400	1250	2	469	24
19	50	24	Wed	13	2621	1193	0.713	856	1200	165	24.00	100.0	50.0	0	1800	170		170		170	200	1313	3	717	24
20	33	24	Thu	14	2958	795	0.564	159	282	22	3.00	12.5	34.0	0	2830	657		657		657	200	688	1	216	24
21	53	24	Fri	15	3594	1260	0.718	798	1112	179	24.00	100.0	46.3	2	2455	1087		1087		1087	400	813	2	437	24
22	39	24	Sat	16	4056	933	0.684	659	963	175	23.25	96.9	41.4	0	2480	1088		1088	4.6	1138	400	875	1	244	24
23	0		Sun	17	4330		0.684	714	1044	172	22.75	94.8	45.9	0	2355	1069		1069	1.9	1089	400	1188	2	409	24
24	0		Mon	18	3616		0.556	644	1158	179	22.75	94.8	50.9	0	2330	1108		1108	0.5	1113	400	1188	2	460	24
25	36	24	Tue	19	2972	859	0.494	613	1241	168	21.25	88.5	58.4	0	2380	1085		1085	1.4	1100	400	1188	2	463	24
26	33	24	Wed	20	3218	794	0.583	582	999	181	24.00	100.0	41.6	0	2536	1099		1099	0	1099	600	1125	2	425	24
27	0		Thu	21	3430		1.013	383	378	62	6.00	25.0	63.0	3	2436	628		628	0	628	200	1250	1	234	24
28	22	24	Fri	22	3047	522	0.419	473	1129	190	24.00	100.0	47.0	0	2186	1022		1022	2.0	1042	400	1375	2	423	24
29	29	24	Sat	23	3096	699	0.569	631	1109	182	24.00	100.0	46.2	1	2293	1109		1109	2.7	1139	400	1313	2	433	24
30	0		Sun	24	3164		0.549	591	1077	168	22.75	94.8	47.3	0	2293	1127		1127	3.1	1162	400	1250	2	433	24
31	0		Mon	25	2573		0.644	631	980	180	24.00	100.0	40.8	0	2243	1005		1005	3.0	1035	400	1250	2	488	24
32	51	24	Tue	26	1942	1220	0.781	427	547	109	14.00	58.3	39.1	0	2218	1066		1066	1.9	1086	400	1375	2	389	24
33	28	24	Wed	27	2735	676	0.572	645	1127	174	20.50	85.4	55.0	0	1699	1032		1032	1.9	1052	400	1375	2	448	24
34	40	24	Thu	28	2766	963	1.034	393	380	59	7.50	31.3	50.7	0	1794	1039		1039	1.2	1051	400	1375	2	345	24
35	42	24	Fri	29	3336	1006	0.590	628	1064	189	24.00	100.0	44.3	0	1135	1089		1089		1089	400	1375	2	462	24
36	39	**28**	**Sat**	**30**	**3714**	**1085**	**0.766**	**763**	**996**	**189**	**23.25**	**96.9**	**42.8**		**1110**	**1083**		**1083**	**1.4**	**1098**	**445**	**1500**	**3**	**657**	**24**
37							0.606				0.00		49.5												
38																									
39			July-1		4036	3733									1023							1521.00			
40	833		MTD Totals		(wet)	20074	0.620	18628	30044	2265	610	84.7	49.3	8		30641	0	30641	1.3	31033	11645		61	13438.5139	720
41	30		MTD Totals		(dry)	18568.5850	0.574	17231.0400																	0.439
42	833		MthEnd Est		(wet)	20074	0.620	18628	30044	2265	609.50	84.7	49.3			30641	0	30641	1.3	31033	11645		61	13439	720
43			MthEnd Est		(dry)	18569	0.574	17231																	0.439
47			**BUDGET -**		(dry)	17,066	0.562	17,414	30,994	1,625	609.50	84.7	50.9					30,994			12,389			12,345	0.398
48			Variance Est vs Plan			1502.6		(183)	(950)									(353)			(744)			1093.63	
49			**Forecast**																						
50			Variance Est vs Flash			18569		17231	30044									30641			11645			13439	



Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O
2	Reporting Day				30							Plan Ratio		0.606
3					Sinter					Daily Max				
4	Plan tons/trk		23.8		Conc					223,700				
5	#Trk	tons/			Beg	Conc	C/S	Conc	Sinter		Oper	%		Acid
6	Conc	Trk	Day	Date	Inv	Rcv'd	Ratio	Use	Made	SO2 (K) Lbs	Hrs	Avail	TPH	Corr
7	33	24	Fri	1	2590	789	0.495	605	1221	181	23.50	97.9	52.0	2
8	46	24	Sat	2	2774	1093	0.604	813	1345	186	24.00	100.0	56.0	0
9	0		Sun	3	3054		0.728	1010	1387	195	24.00	100.0	57.8	0
10	0		Mon	4	2044		0.597	854	1430	135	24.00	100.0	59.6	0
11	44	24	Tue	5	1190	1042	0.660	155	235	22	6.50	27.1	36.2	0
12	46	24	Wed	6	2077	1097	0.551	601	1090	103	14.25	59.4	76.5	0
13	55	24	Thu	7	2573	1323	0.785	716	912	86	24.00	100.0	38.0	0
14	34	24	Fri	8	3180	810	0.563	651	1156	168	23.00	95.8	50.3	0
15	44	24	Sat	9	3339	1059	0.497	469	943	155	20.75	86.5	45.4	0
16	0		Sun	10	3929		0.585	647	1106	174	22.50	93.8	49.2	0
17	0		Mon	11	3282		0.584	766	1311	195	24.00	100.0	54.6	0
18	36	24	Tue	12	2516	856	0.669	751	1122	190	24.00	100.0	46.8	0
19	50	24	Wed	13	2621	1193	0.713	856	1200	165	24.00	100.0	50.0	0
20	33	24	Thu	14	2958	795	0.564	159	282	22	3.00	12.5	94.0	0
21	53	24	Fri	15	3594	1260	0.718	798	1112	179	24.00	100.0	46.3	2
22	39	24	Sat	16	4056	933	0.684	659	963	175	23.25	96.9	41.4	0
23	0		Sun	17	4330		0.684	714	1044	172	22.75	94.8	45.9	0
24	0		Mon	18	3616		0.556	644	1158	179	22.75	94.8	50.9	0
25	36	24	Tue	19	2972	859	0.494	613	1241	168	21.25	88.5	58.4	0
26	33	24	Wed	20	3218	794	0.583	582	999	181	24.00	100.0	41.6	0
27	0		Thu	21	3430		1.013	383	378	62	6.00	25.0	63.0	3
28	22	24	Fri	22	3047	522	0.419	473	1129	190	24.00	100.0	47.0	0
29	29	24	Sat	23	3096	699	0.569	631	1109	182	24.00	100.0	46.2	1
30	0		Sun	24	3164		0.549	591	1077	168	22.75	94.8	47.3	0
31	0		Mon	25	2573		0.644	631	980	180	24.00	100.0	40.8	0
32	51	24	Tue	26	1942	1220	0.781	427	547	109	14.00	58.3	39.1	0
33	28	24	Wed	27	2735	676	0.572	645	1127	174	20.50	85.4	55.0	0
34	40	24	Thu	28	2766	963	1.034	393	380	59	7.50	31.3	50.7	0
35	42	24	Fri	29	3336	1006	0.590	628	1064	189	24.00	100.0	44.3	0
36	39	**28**	**Sat**	**30**	**3714**	**1085**	**0.766**	**763**	**996**	**189**	**23.25**	**96.9**	**42.8**	
37							0.606				0.00		49.5	
38														
39			July-1		4036	3733								
40	833		MTD Totals		(wst)	20074	0.620	18628	30044	2265	610	84.7	49.3	8
41	30		MTD Totals		(dry)	18568.5850	0.574	17231.0400						
42	833		MthEnd Est		(wst)	20074	0.620	18628	30044	2265	609.50	84.7	49.3	
43			MthEnd Est		(dry)	18569	0.574	17231						
47			**BUDGET -**		(dry)	17,066	0.562	17,414	30,994	1,625	609.50	84.7	50.9	
48			Variance Est w Plan			1502.6		(183)	(950)					
49			**Forecast**											
50			Variance Est w Flash			18569		17231	30044					

Row	Q	R	S	T	U	V	W	Y	Z	AA	AC
2				Plan Yield on Charge		0.40509		Plan yield on DeCu'd		99.29%	
3	Furnace							Refinery			
4	Sinter							Lead			
5	Beg	------Sinter Use------			%	Total	DeCu'd	Beg	#Lutr	Fin Gds	
6	Inv	BF 1	BF 2	Total	2nd's	Charge	Pump'd	WIP	Cast	Cast	
7	1620	946		946		946	200	1375	2	452	24
8	1895	1195		1195		1195	400	1063	2	385	24
9	2045	1187		1187		1187	600	1375	2	410	24
10	2245	1155		1155		1155	400	1438	2	459	24
11	2520	917		917		917	400	1438	3	727	24
12	1838	990		990	2.0	1010	400	1188	2	455	24
13	1938	1102		1102	2.7	1132	400	1250	2	454	24
14	1748	1081		1081	4.6	1131	400	1313	3	670	24
15	1823	1166		1166		1166	400	1250	2	429	24
16	1600	1056		1056		1056	400	1188	2	484	24
17	1650	1186		1186		1186	400	1250	2	361	24
18	1775	1097		1097	1.8	1117	400	1250	2	469	24
19	1800	170		170		170	200	1313	3	717	24
20	2830	657		657		657	200	688	1	216	24
21	2455	1087		1087		1087	400	813	2	437	24
22	2480	1088		1088	4.6	1138	400	875	1	244	24
23	2355	1069		1069	1.9	1089	400	1188	2	409	24
24	2330	1108		1108	0.5	1113	400	1188	2	460	24
25	2380	1085		1085	1.4	1100	400	1188	2	463	24
26	2536	1099		1099	0	1099	600	1125	2	425	24
27	2436	628		628	0	628	200	1250	1	234	24
28	2186	1022		1022	2.0	1042	400	1375	2	423	24
29	2293	1109		1109	2.7	1139	400	1313	2	433	24
30	2293	1127		1127	3.1	1162	400	1250	2	433	24
31	2243	1005		1005	3.0	1035	400	1250	2	488	24
32	2218	1066		1066	1.9	1086	400	1375	2	389	24
33	1699	1032		1032	1.9	1052	400	1375	2	448	24
34	1794	1039		1039	1.2	1051	400	1375	2	345	24
35	1135	1089		1089		1089	400	1375	2	462	24
36	**1110**	**1083**		**1083**	**1.4**	**1098**	**445**	**1500**	**3**	**657**	**24**
39	1023							1521.00			
40		30641	0	30641	1.3	31033	11645		61	13438.5139	720
41											0.439
42		30641	0	30641	1.3	31033	11645		61	13439	720
43											0.439
47				30,994			12,389			12,345	0.398
48				(353)			(744)			1093.63	
50				30641			11645			13439	



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel

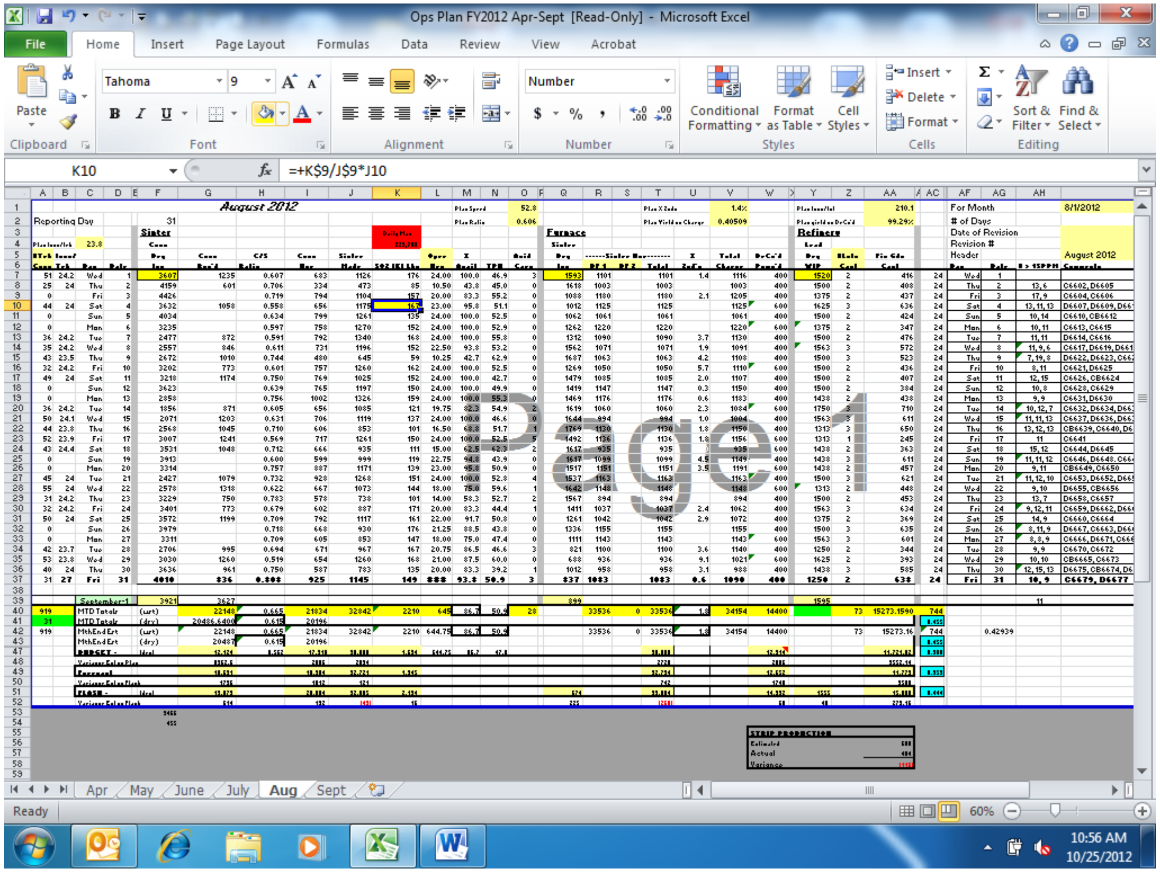
K13 =$K$10/$J$10*J13

Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC
2	Reporting Day				30							Plan Ratio		0.606				Plan Yield on Charge		0.40509		Plan yield on DeCu'd		99.29%	
3					**Sinter**					Daily Max					**Furnace**							**Refinery**			
4	Plan tons/trk		23.8		Conc					223,700					Sinter							Lead			
5	#Trk	tons/			Beg	Conc	C/S	Conc	Sinter		Oper	%		Acid	Beg	------Sinter Use------			%	Total	DeCu'd	Beg	#Lstr	Fin Gdr	
6	Conc	Trk	Day	Date	Inv	Rcv'd	Ratio	Use	Made	SO2 (K) Lbs	Hrs	Avail	TPH	Cars	Inv	BF 1	BF 2	Total	2nd's	Charge	Pump'd	WIP	Cast	Cast	
7	33	24	Fri	1	2590	789	0.495	605	1221	181	23.50	97.9	52.0	2	1620	946		946		946	200	1375	2	452	24
8	46	24	Sat	2	2774	1093	0.604	813	1345	186	24.00	100.0	56.0	0	1895	1195		1195		1195	400	1063	2	385	24
9	0		Sun	3	3054		0.728	1010	1387	195	24.00	100.0	57.8	0	2045	1187		1187		1187	600	1375	2	410	24
10	0		Mon	4	2044		0.597	854	1430	135	24.00	100.0	59.6	0	2245	1155		1155		1155	400	1438	2	459	24
11	44	24	Tue	5	1190	1042	0.660	155	235	22	6.50	27.1	36.2	0	2520	917		917		917	400	1438	3	727	24
12	46	24	Wed	6	2077	1097	0.551	601	1090	103	14.25	59.4	76.5	0	1838	990		990	2.0	1010	400	1188	2	455	24
13	55	24	Thu	7	2573	1323	0.785	716	912	86	24.00	100.0	38.0	0	1938	1102		1102	2.7	1132	400	1250	2	454	24
14	34	24	Fri	8	3180	810	0.563	651	1156	168	23.00	95.8	50.3	0	1748	1081		1081	4.6	1131	400	1313	3	670	24
15	44	24	Sat	9	3339	1059	0.497	469	943	155	20.75	86.5	45.4	0	1823	1166		1166		1166	400	1250	2	429	24
16	0		Sun	10	3929		0.585	647	1106	174	22.50	93.8	49.2	0	1600	1056		1056		1056	400	1188	2	484	24
17	0		Mon	11	3282		0.584	766	1311	195	24.00	100.0	54.6	0	1650	1186		1186		1186	400	1250	2	361	24
18	36	24	Tue	12	2516	856	0.669	751	1122	190	24.00	100.0	46.8	0	1775	1097		1097	1.8	1117	400	1250	2	469	24
19	50	24	Wed	13	2621	1193	0.713	856	1200	165	24.00	100.0	50.0	0	1800	170		170		170	200	1313	3	717	24
20	33	24	Thu	14	2958	795	0.564	159	282	22	3.00	12.5	94.0	0	2830	657		657		657	200	688	1	216	24
21	53	24	Fri	15	3594	1260	0.718	798	1112	179	24.00	100.0	46.3	2	2455	1087		1087		1087	400	813	2	437	24
22	39	24	Sat	16	4056	933	0.684	659	963	175	23.25	96.9	41.4	0	2480	1088		1088	4.6	1138	400	875	1	244	24
23	0		Sun	17	4330		0.684	714	1044	172	22.75	94.8	45.9	0	2355	1069		1069	1.9	1089	400	1188	2	409	24
24	0		Mon	18	3616		0.556	644	1158	179	22.75	94.8	50.9	0	2330	1108		1108	0.5	1113	400	1188	2	460	24
25	36	24	Tue	19	2972	859	0.494	613	1241	168	21.25	88.5	58.4	0	2380	1085		1085	1.4	1100	400	1188	2	463	24
26	33	24	Wed	20	3218	794	0.583	582	999	181	24.00	100.0	41.6	0	2536	1099		1099	0	1099	600	1125	2	425	24
27	0		Thu	21	3430		1.013	383	378	62	6.00	25.0	63.0	3	2436	628		628	[illegible]	628	200	1250	1	234	24
28	22	24	Fri	22	3047	522	0.419	473	1129	190	24.00	100.0	47.0	0	2186	1022		1022	2.0	1042	400	1375	2	423	24
29	29	24	Sat	23	3096	699	0.569	631	1109	182	24.00	100.0	46.2	1	2293	1109		1109	2.7	1139	400	1313	2	433	24
30	0		Sun	24	3164		0.549	591	1077	168	22.75	94.8	47.3	0	2293	1127		1127	3.1	1162	400	1250	2	433	24
31	0		Mon	25	2573		0.644	631	980	180	24.00	100.0	40.8	0	2243	1005		1005	3.0	1035	400	1250	2	488	24
32	51	24	Tue	26	1942	1220	0.781	427	547	109	14.00	58.3	39.1	0	2218	1066		1066	1.9	1086	400	1375	2	389	24
33	28	24	Wed	27	2735	676	0.572	645	1127	174	20.50	85.4	55.0	0	1699	1032		1032	1.9	1052	400	1375	2	448	24
34	40	24	Thu	28	2766	963	1.034	393	380	59	7.50	31.3	50.7	0	1794	1039		1039	1.2	1051	400	1375	2	345	24
35	42	24	Fri	29	3336	1006	0.590	628	1064	189	24.00	100.0	44.3	0	1135	1089		1089		1089	400	1375	2	462	24
36	39	**28**	**Sat**	**30**	**3714**	**1085**	**0.766**	**763**	**996**	**189**	**23.25**	**96.9**	**42.8**		**1110**	**1083**		**1083**	**1.4**	**1098**	**445**	**1500**	**3**	**657**	**24**
37							0.606				0.00		49.5												
38																									
39			July-1		4036	3733									1023							1521.00			
40	833		MTD Totals		(wst)	20074	0.620	18628	30044	2265	610	84.7	49.3	8		30641	0	30641	1.3	31033	11645		61	13438.5139	720
41	30		MTD Totals		(dry)	18568.5850	0.574	17231.0400																	0.439
42	833		MthEnd Est		(wst)	20074	0.620	18628	30044	2265	609.50	84.7	49.3			30641	0	30641	1.3	31033	11645		61	13439	720
43			MthEnd Est		(dry)	18569	0.574	17231																	0.439
47			BUDGET -		(dry)	17,066	0.562	17,414	30,994	1,625	609.50	84.7	50.9					30,994			12,389			12,345	0.398
48			Variance Est vs Plan			1502.6		(183)	(950)									(353)			(744)			1093.63	
49			Forecast																						
50			Variance Est vs Flash			18569		17231	30044									30641			11645			13439	

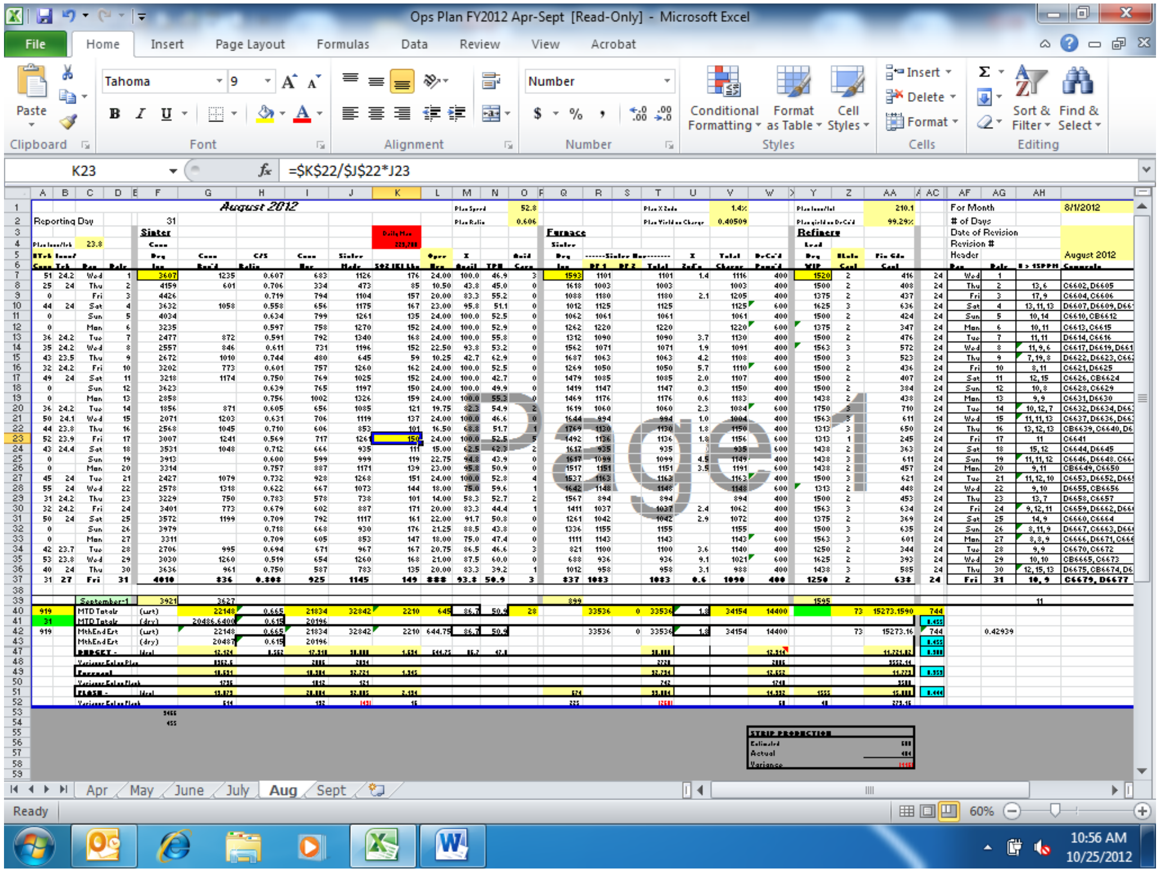
Apr | May | June | July | Aug | Sept

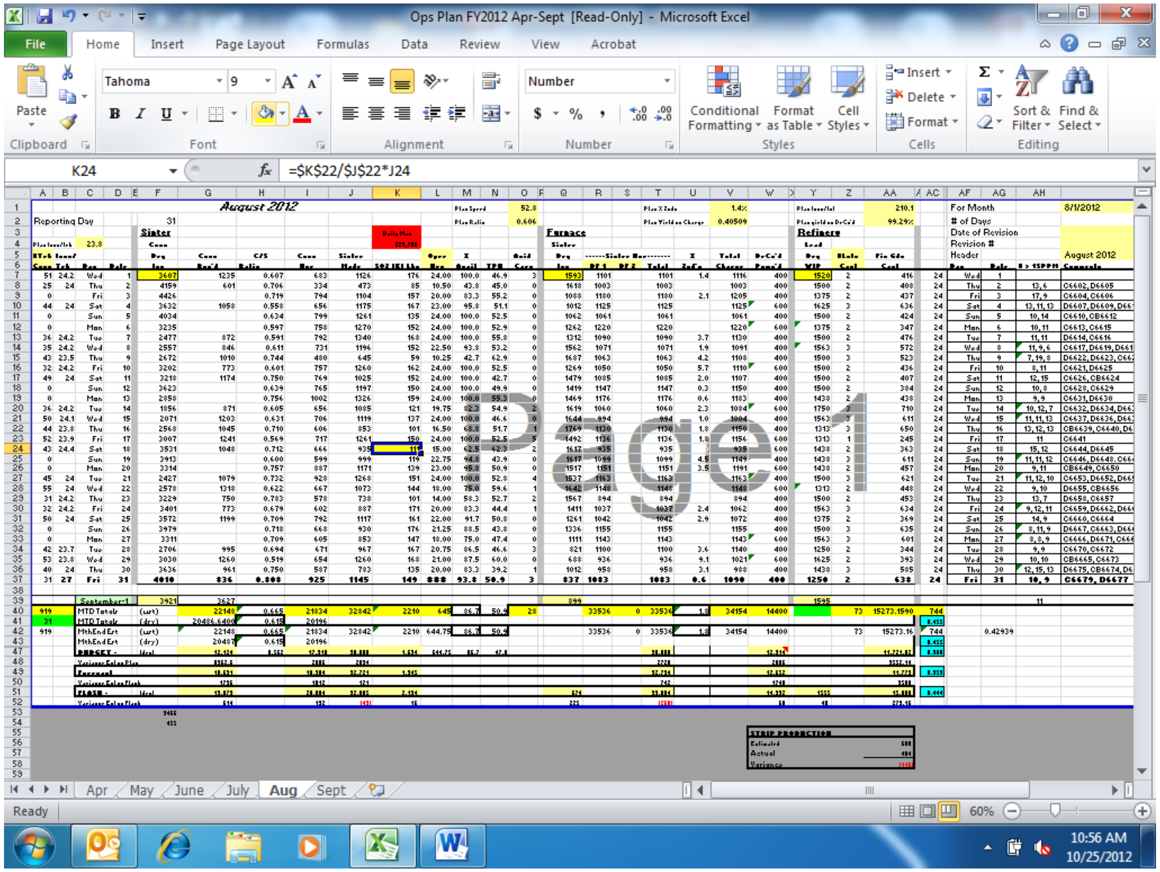
Ready 70%

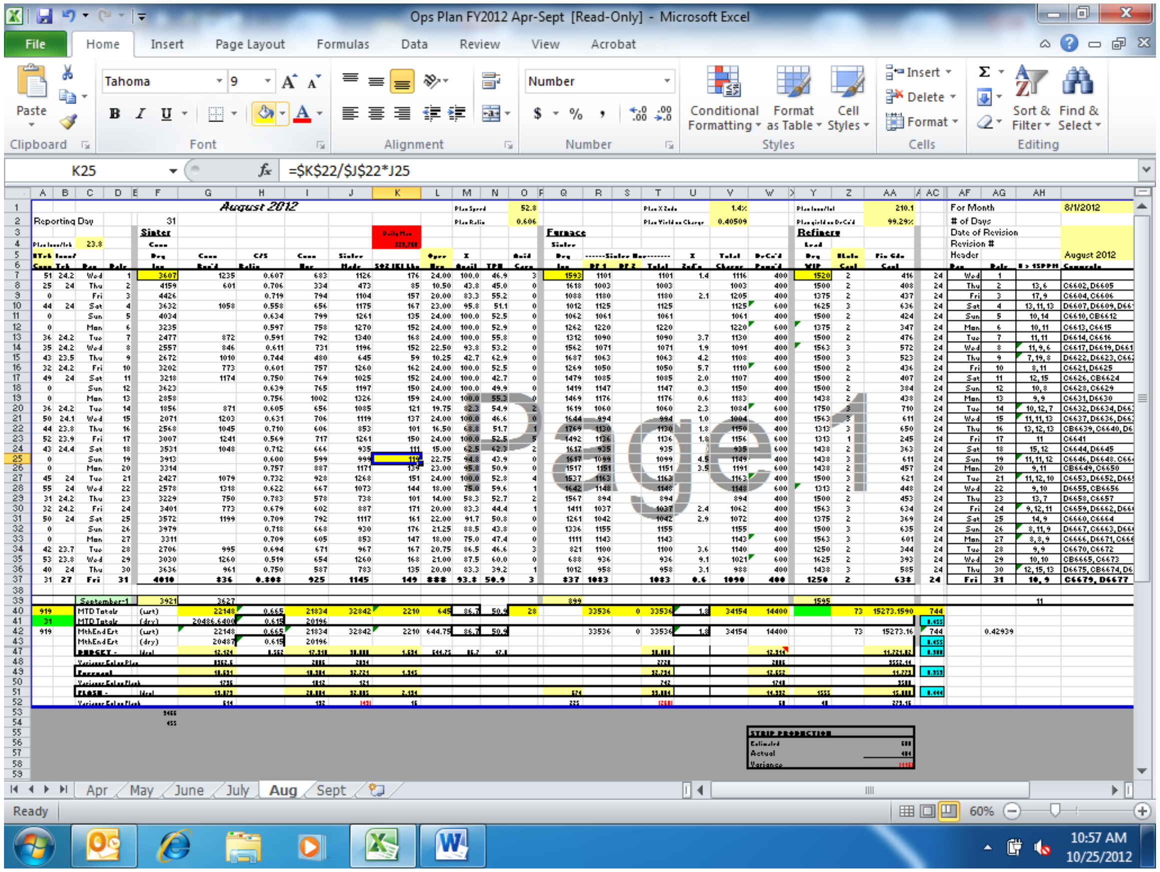
10:55 AM 10/25/2012



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Tahoma
9
Number
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
K10
=+K$9/J$9*J10
August 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
8/1/2012
# of Days
Date of Revision
Revision #
Header
August 2012
MTD Totals
MthEnd Est
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:56 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Tahoma
9
Number
Paste
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
K23
=$K$22/$J$22*J23
August 2012
Reporting Day
Sinter
Furnace
Refinery
For Month
8/1/2012
# of Days
Date of Revision
Revision #
Header
August 2012
MTD Totals
MthEnd Est
Page 1
STRIP PRODUCTION
Apr
May
June
July
Aug
Sept
Ready
60%
10:56 AM
10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
Tahoma
9
Number
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
K24
=$K$22/$J$22*J24
August 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
8/1/2012
# of Days
Date of Revision
Revision #
Header
August 2012
MTD Totals
MthEnd Est
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:56 AM
10/25/2012



August 2012

Reporting Day 31

Plan Speed 52.8 | Plan Ratio 0.606 | Plan X Zn 1.4% | Plan Yield on Charge 0.40509 | Plan lead/tel 210.1 | Plan yield on DrCu'd 99.29%

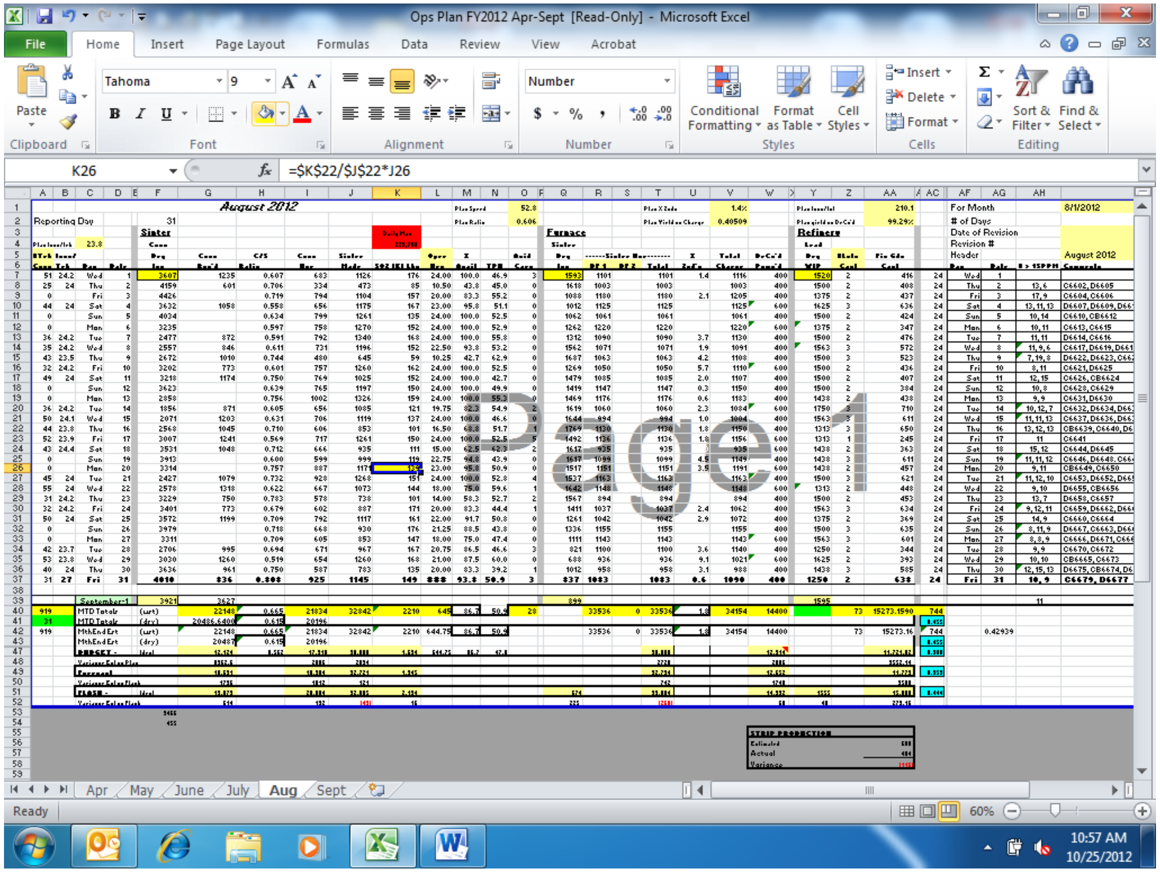
Daily Max 225,700

Plan lead/tek 23.8

For Month 8/1/2012
# of Days
Date of Revision
Revision #
Header August 2012

Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	Y	Z	AA	AC	AF	AG	AH	AI
3					Sinter										Furnace							Refinery							
4					Conc										Sinter							Lead							
5	WTek Issue/				Dry	Conc	C/S	Conc	Sinter		Oper	%		Acid	Dry	------Sinter			%	Total	DrCu'd	Dry	Slab	Fin Gds					
6	Conc	Tek	Day	Date	Ton	Rec'd	Ratio	Bar	Made	[illegible]	Hrs	Avail	TPH	Conv	Ton	RF 1	RF 2	Total	ZnCn	Charge	[illegible]	WIP	Cast	Cast		Day	Date	# > 15PPM	Comments
7	51	24.2	Wed	1	3607	1235	0.607	683	1126	176	24.00	100.0	46.9	3	1593	1101		1101	1.4	1116	400	1520	2	416	24	Wed	1		
8	25	24	Thu	2	4159	601	0.706	334	473	85	10.50	43.8	45.0	0	1618	1003		1003		1003	400	1500	2	408	24	Thu	2	13, 6	C6602, D6605
9	0		Fri	3	4426		0.719	794	1104	157	20.00	83.3	55.2	0	1088	1180		1180	2.1	1205	400	1375	2	437	24	Fri	3	17, 9	C6604, C6606
10	44	24	Sat	4	3632	1058	0.558	656	1175	167	23.00	95.8	51.1	0	1012	1125		1125		1125	600	1625	3	636	24	Sat	4	13, 11, 13	D6607, D6609, D66
11	0		Sun	5	4034		0.634	799	1261	135	24.00	100.0	52.5	0	1062	1061		1061		1061	400	1500	2	424	24	Sun	5	10, 14	C6610, CB6612
12	0		Mon	6	3235		0.597	758	1270	152	24.00	100.0	52.9	0	1262	1220		1220		1220	600	1375	2	347	24	Mon	6	10, 11	C6613, C6615
13	36	24.2	Tue	7	2477	872	0.591	792	1340	168	24.00	100.0	55.8	0	1312	1090		1090	3.7	1130	400	1500	2	476	24	Tue	7	11, 11	D6614, C6616
14	35	24.2	Wed	8	2557	846	0.611	731	1196	152	22.50	93.8	53.2	0	1562	1071		1071	1.9	1091	400	1563	3	572	24	Wed	8	11, 9, 6	C6617, D6619, D661
15	43	23.5	Thu	9	2672	1010	0.744	480	645	59	10.25	42.7	62.9	0	1687	1063		1063	4.2	1108	400	1500	3	523	24	Thu	9	7, 19, 8	D6622, D6623, C66
16	32	24.2	Fri	10	3202	773	0.601	757	1260	162	24.00	100.0	52.5	0	1269	1050		1050	5.7	1110	600	1500	2	436	24	Fri	10	8, 11	C6621, D6625
17	49	24	Sat	11	3218	1174	0.750	769	1025	152	24.00	100.0	42.7	0	1479	1085		1085	2.0	1107	400	1500	2	407	24	Sat	11	12, 15	C6626, CB6624
18	0		Sun	12	3623		0.639	765	1197	150	24.00	100.0	49.9	0	1419	1147		1147	0.3	1150	400	1500	2	384	24	Sun	12	10, 8	C6628, C6629
19	0		Mon	13	2858		0.756	1002	1326	159	24.00	100.0	55.3	0	1469	1176		1176	0.6	1183	400	1438	2	438	24	Mon	13	9, 9	C6631, D6630
20	36	24.2	Tue	14	1856	871	0.605	656	1085	121	19.75	82.3	54.9	2	1619	1060		1060	2.3	1084	600	1750	3	710	24	Tue	14	10, 12, 7	C6632, D6634, D66
21	50	24.1	Wed	15	2071	1203	0.631	706	1119	137	24.00	100.0	46.6	0	1644	994		994	1.0	1004	400	1563	3	611	24	Wed	15	11, 11, 13	C6637, D6636, D66
22	44	23.8	Thu	16	2568	1045	0.710	606	853	101	16.50	68.8	51.7	1	1769	1130		1130	1.8	1150	400	1313	3	650	24	Thu	16	13, 12, 13	CB6639, C6640, D6
23	52	23.9	Fri	17	3007	1241	0.569	717	1261	150	24.00	100.0	52.5	5	1492	1136		1136	1.8	1156	600	1313	1	245	24	Fri	17	11	C6641
24	43	24.4	Sat	18	3531	1048	0.712	666	935	111	15.00	62.5	62.3	2	1617	935		935		935	600	1438	2	363	24	Sat	18	15, 12	C6644, D6645
25	0		Sun	19	3913		0.600	599	999	119	22.75	94.8	43.9	0	1617	1099		1099	4.5	1149	400	1438	3	611	24	Sun	19	11, 11, 12	C6646, D6648. C66
26	0		Mon	20	3314		0.757	887	1171	139	23.00	95.8	50.9	0	1517	1151		1151	3.5	1191	600	1438	2	457	24	Mon	20	9, 11	CB6649, C6650
27	45	24	Tue	21	2427	1079	0.732	928	1268	151	24.00	100.0	52.8	4	1537	1163		1163		1163	400	1500	3	621	24	Tue	21	11, 12, 10	C6653, D6652, D66
28	55	24	Wed	22	2578	1318	0.622	667	1073	144	18.00	75.0	59.6	1	1642	1148		1148		1148	600	1313	2	448	24	Wed	22	9, 10	D6655, CB6656
29	31	24.2	Thu	23	3229	750	0.783	578	738	101	14.00	58.3	52.7	2	1567	894		894		894	400	1500	2	453	24	Thu	23	13, 7	D6658, C6657
30	32	24.2	Fri	24	3401	773	0.679	602	887	171	20.00	83.3	44.4	1	1411	1037		1037	2.4	1062	400	1563	3	634	24	Fri	24	9, 12, 11	C6659, D6662, D66
31	50	24	Sat	25	3572	1199	0.709	792	1117	161	22.00	91.7	50.8	0	1261	1042		1042	2.9	1072	400	1375	2	369	24	Sat	25	14, 9	C6660, C6664
32	0		Sun	26	3979		0.718	668	930	176	21.25	88.5	43.8	0	1336	1155		1155		1155	400	1500	3	635	24	Sun	26	8, 11, 9	D6667, C6663, D66
33	0		Mon	27	3311		0.709	605	853	147	18.00	75.0	47.4	0	1111	1143		1143		1143	600	1563	3	601	24	Mon	27	8, 8, 9	C6666, D6671, C66
34	42	23.7	Tue	28	2706	995	0.694	671	967	167	20.75	86.5	46.6	3	821	1100		1100	3.6	1140	400	1250	2	344	24	Tue	28	9, 9	C6670, C6672
35	53	23.8	Wed	29	3030	1260	0.519	654	1260	168	21.00	87.5	60.0	0	688	936		936	9.1	1021	600	1625	2	393	24	Wed	29	10, 10	CB6665, C6673
36	40	24	Thu	30	3636	961	0.750	587	783	135	20.00	83.3	39.2	1	1012	958		958	3.1	988	400	1438	3	585	24	Thu	30	12, 15, 13	D6675, CB6674, D6
37	31	27	Fri	31	4010	836	0.808	925	1145	149	[illegible]	93.8	50.9	3	837	1083		1083	0.6	1090	400	1250	2	638	24	Fri	31	10, 9	C6679, D6677
39			September-1		3921	3627									899							1595						11	
40	919		MTD Totals	(wet)		22148	0.665	21834	32842	2210	645	86.7	50.9	28		33536	0	33536	1.8	34154	14400		73	15273.1590	744				
41	31		MTD Totals	(dry)		20486.6400	0.615	20196																	0.455				
42	919		MthEnd Est	(wet)		22148	0.665	21834	32842	2210	644.75	86.7	50.9			33536	0	33536	1.8	34154	14400		73	15273.16	744		0.42939		
43			MthEnd Est	(dry)		20487	0.615	20196																	0.455				
47			BUDGET -	Ideal		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	644.75	86.7	47.8					[illegible]			[illegible]			[illegible]	[illegible]				
48			[illegible]			[illegible]		[illegible]	[illegible]									[illegible]			[illegible]			[illegible]					
49			Forecast			[illegible]		[illegible]	[illegible]	[illegible]								[illegible]			[illegible]			[illegible]	[illegible]				
50			[illegible]			[illegible]		[illegible]	[illegible]									[illegible]			[illegible]			[illegible]					
51			FLASH -	Ideal		[illegible]		[illegible]	[illegible]	[illegible]					[illegible]			[illegible]			[illegible]	[illegible]		[illegible]	[illegible]				
52			[illegible]			[illegible]		[illegible]	[illegible]	[illegible]					[illegible]			[illegible]			[illegible]	[illegible]		[illegible]					
53					[illegible]																								
54					455																								

STRIP PRODUCTION	
Estimated	[illegible]
Actual	[illegible]
Variance	[illegible]



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel

K26 =$K$22/$J$22*J26

August 2012

Reporting Day 31

Sinter | Furnace | Refinery

Plan Speed 52.8 | Plan Ratio 0.606 | Plan X Zinc 1.4% | Plan Yield on Charge 0.40509 | Plan yield on DeCu'd 99.29% | Plan tons/trk 23.8 | Daily Max | 210.1

For Month 8/1/2012
# of Days
Date of Revision
Revision #
Header August 2012

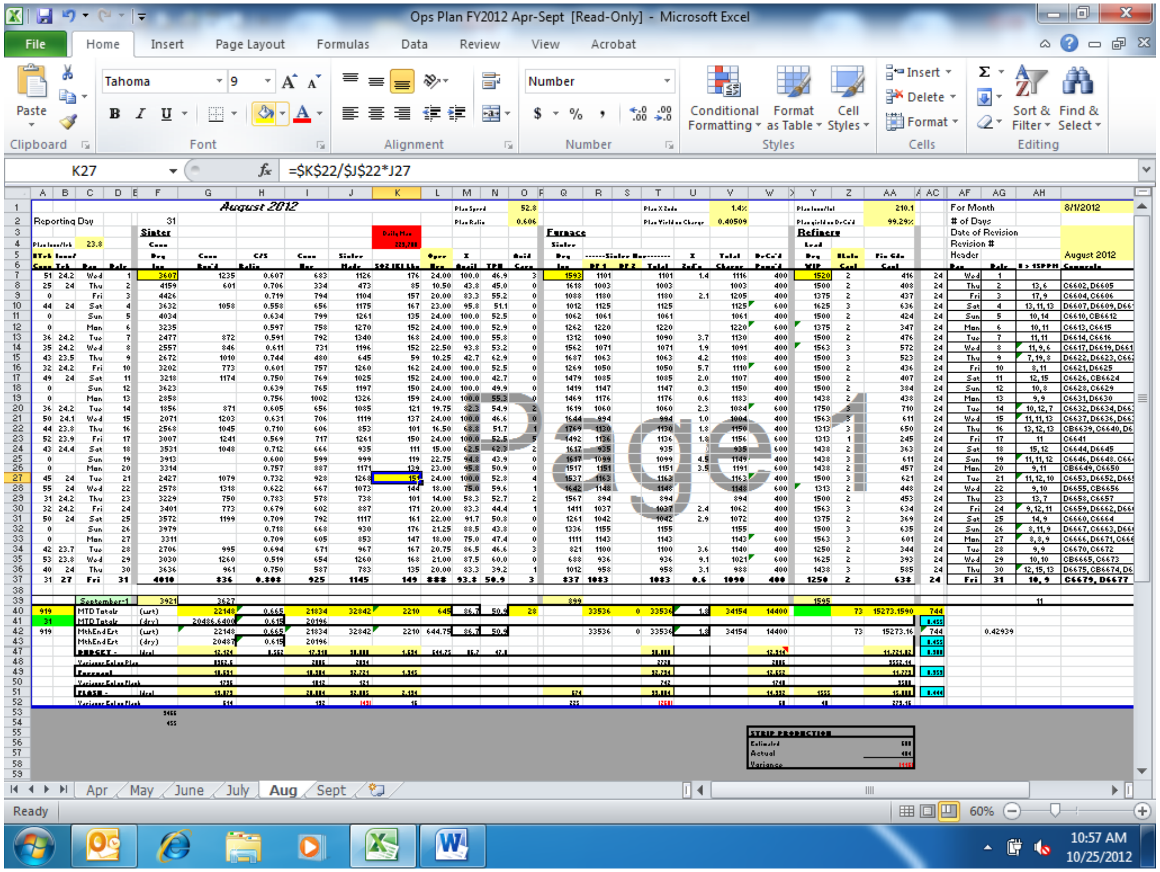
Row	A	B	C	D	F	G	H	I	J	K	L	M	N	O
7	51	24.2	Wed	1	3607	1235	0.607	683	1126	176	24.00	100.0	46.9	3
8	25	24	Thu	2	4159	601	0.706	334	473	85	10.50	43.8	45.0	0
9	0		Fri	3	4426		0.719	794	1104	157	20.00	83.3	55.2	0
10	44	24	Sat	4	3632	1058	0.558	656	1175	167	23.00	95.8	51.1	0
11	0		Sun	5	4034		0.634	799	1261	135	24.00	100.0	52.5	0
12	0		Mon	6	3235		0.597	758	1270	152	24.00	100.0	52.9	0
13	36	24.2	Tue	7	2477	872	0.591	792	1340	168	24.00	100.0	55.8	0
14	35	24.2	Wed	8	2557	846	0.611	731	1196	152	22.50	93.8	53.2	0
15	43	23.5	Thu	9	2672	1010	0.744	480	645	59	10.25	42.7	62.9	0
16	32	24.2	Fri	10	3202	773	0.601	757	1260	162	24.00	100.0	52.5	0
17	49	24	Sat	11	3218	1174	0.750	769	1025	152	24.00	100.0	42.7	0
18	0		Sun	12	3623		0.639	765	1197	150	24.00	100.0	49.9	0
19	0		Mon	13	2858		0.756	1002	1326	159	24.00	100.0	55.3	0
20	36	24.2	Tue	14	1856	871	0.605	656	1085	121	19.75	82.3	54.9	2
21	50	24.1	Wed	15	2071	1203	0.631	706	1119	137	24.00	100.0	46.6	0
22	44	23.8	Thu	16	2568	1045	0.710	606	853	101	16.50	68.8	51.7	1
23	52	23.9	Fri	17	3007	1241	0.569	717	1261	150	24.00	100.0	52.5	5
24	43	24.4	Sat	18	3531	1048	0.712	666	935	111	15.00	62.5	62.3	2
25	0		Sun	19	3913		0.600	599	999	119	22.75	94.8	43.9	0
26	0		Mon	20	3314		0.757	887	1171	139	23.00	95.8	50.9	0
27	45	24	Tue	21	2427	1079	0.732	928	1268	151	24.00	100.0	52.8	4
28	55	24	Wed	22	2578	1318	0.622	667	1073	144	18.00	75.0	59.6	1
29	31	24.2	Thu	23	3229	750	0.783	578	738	101	14.00	58.3	52.7	2
30	32	24.2	Fri	24	3401	773	0.679	602	887	171	20.00	83.3	44.4	1
31	50	24	Sat	25	3572	1199	0.709	792	1117	161	22.00	91.7	50.8	0
32	0		Sun	26	3979		0.718	668	930	176	21.25	88.5	43.8	0
33	0		Mon	27	3311		0.709	605	853	147	18.00	75.0	47.4	0
34	42	23.7	Tue	28	2706	995	0.694	671	967	167	20.75	86.5	46.6	3
35	53	23.8	Wed	29	3030	1260	0.519	654	1260	168	21.00	87.5	60.0	0
36	40	24	Thu	30	3636	961	0.750	587	783	135	20.00	83.3	39.2	1
37	31	27	Fri	31	4010	836	0.808	925	1145	149	###	93.8	50.9	3
39			September-1		3921	3627								
40	919		MTD Totals		(wet)	22148	0.665	21834	32842	2210	645	86.7	50.9	28
41	31		MTD Totals		(dry)	20486.6400	0.615	20196						
42	919		MthEnd Est		(wet)	22148	0.665	21834	32842	2210	644.75	86.7	50.9	
43			MthEnd Est		(dry)	20487	0.615	20196						

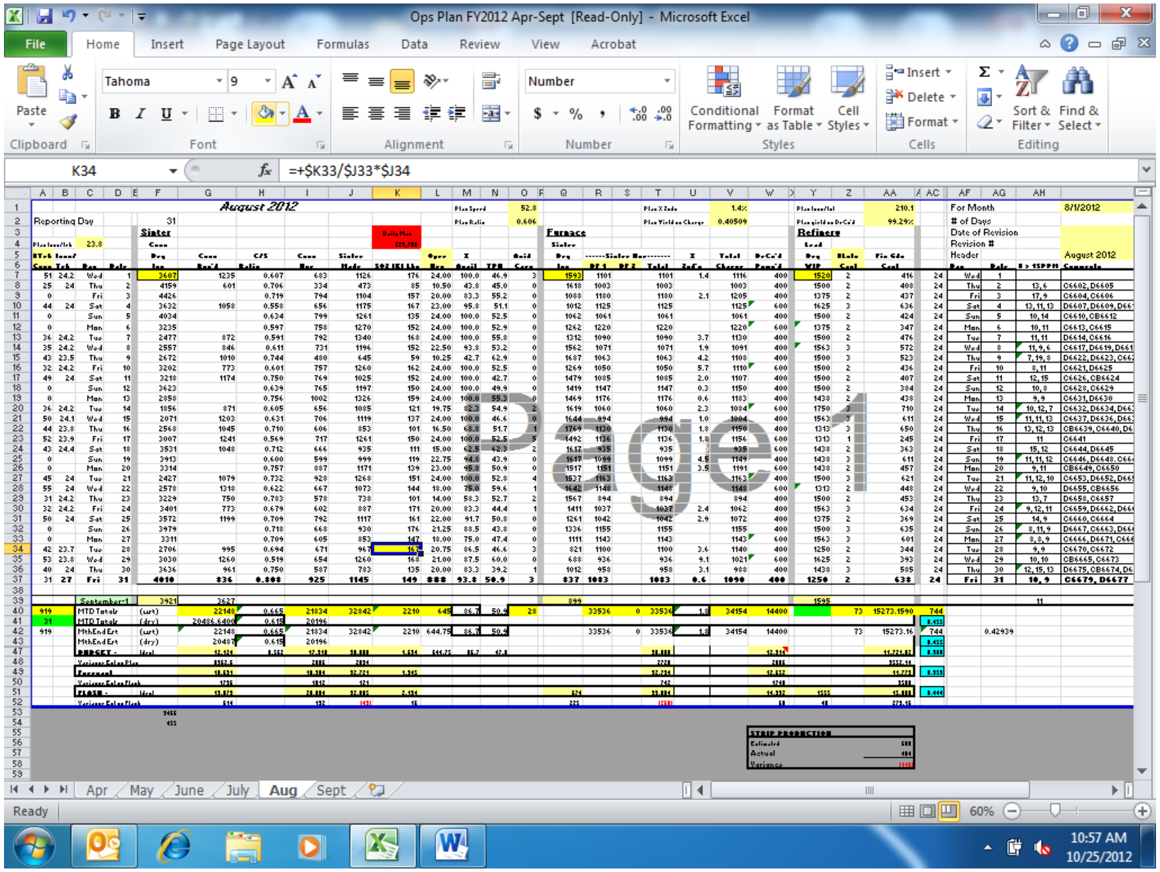
Row	Q	R	S	T	U	V	W	Y	Z	AA	AC	AF	AG	AH	AI
7	1593	1101		1101	1.4	1116	400	1520	2	416	24	Wed	1		
8	1618	1003		1003		1003	400	1500	2	408	24	Thu	2	13, 6	C6602, D6605
9	1088	1180		1180	2.1	1205	400	1375	2	437	24	Fri	3	17, 9	C6604, C6606
10	1012	1125		1125		1125	600	1625	3	636	24	Sat	4	13, 11, 13	D6607, D6609, D66
11	1062	1061		1061		1061	400	1500	2	424	24	Sun	5	10, 14	C6610, CB6612
12	1262	1220		1220		1220	600	1375	2	347	24	Mon	6	10, 11	C6613, C6615
13	1312	1090		1090	3.7	1130	400	1500	2	476	24	Tue	7	11, 11	D6614, C6616
14	1562	1071		1071	1.9	1091	400	1563	3	572	24	Wed	8	11, 9, 6	C6617, D6619, D661
15	1687	1063		1063	4.2	1108	400	1500	3	523	24	Thu	9	7, 19, 8	D6622, D6623, C66
16	1269	1050		1050	5.7	1110	600	1500	2	436	24	Fri	10	8, 11	C6621, D6625
17	1479	1085		1085	2.0	1107	400	1500	2	407	24	Sat	11	12, 15	C6626, CB6624
18	1419	1147		1147	0.3	1150	400	1500	2	384	24	Sun	12	10, 8	C6628, C6629
19	1469	1176		1176	0.6	1183	400	1438	2	438	24	Mon	13	9, 9	C6631, D6630
20	1619	1060		1060	2.3	1084	600	1750	3	710	24	Tue	14	10, 12, 7	C6632, D6634, D66
21	1644	994		994	1.0	1004	400	1563	3	611	24	Wed	15	11, 11, 13	C6637, D6636, D66
22	1769	1130		1130	1.8	1150	400	1313	3	650	24	Thu	16	13, 12, 13	CB6639, C6640, D6
23	1492	1136		1136	1.8	1156	600	1313	1	245	24	Fri	17	11	C6641
24	1617	935		935		935	600	1438	2	363	24	Sat	18	15, 12	C6644, D6645
25	1617	1099		1099	4.5	1149	400	1438	3	611	24	Sun	19	11, 11, 12	C6646, D6648, C66
26	1517	1151		1151	3.5	1191	600	1438	2	457	24	Mon	20	9, 11	CB6649, C6650
27	1537	1163		1163		1163	400	1500	3	621	24	Tue	21	11, 12, 10	C6653, D6652, D66
28	1642	1148		1148		1148	600	1313	2	448	24	Wed	22	9, 10	D6655, CB6656
29	1567	894		894		894	400	1500	2	453	24	Thu	23	13, 7	D6658, C6657
30	1411	1037		1037	2.4	1062	400	1563	3	634	24	Fri	24	9, 12, 11	C6659, D6662, D66
31	1261	1042		1042	2.9	1072	400	1375	2	369	24	Sat	25	14, 9	C6660, C6664
32	1336	1155		1155		1155	400	1500	3	635	24	Sun	26	8, 11, 9	D6667, C6663, D66
33	1111	1143		1143		1143	600	1563	3	601	24	Mon	27	8, 8, 9	C6666, D6671, C66
34	821	1100		1100	3.6	1140	400	1250	2	344	24	Tue	28	9, 9	C6670, C6672
35	688	936		936	9.1	1021	600	1625	2	393	24	Wed	29	10, 10	CB6665, C6673
36	1012	958		958	3.1	988	400	1438	3	585	24	Thu	30	12, 15, 13	D6675, CB6674, D6
37	837	1083		1083	0.6	1090	400	1250	2	638	24	Fri	31	10, 9	C6679, D6677
39	899							1595						11	
40		33536	0	33536	1.8	34154	14400		73	15273.1590	744				
41											0.455				
42		33536	0	33536	1.8	34154	14400		73	15273.16	744		0.42939		
43											0.455				

Apr May June July Aug Sept

Ready 60%

10:57 AM 10/25/2012


Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K27
=$K$22/$J$22*J27
August 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
8/1/2012
# of Days
Date of Revision
Revision #
Header
August 2012
MTD Totals
MthEnd Est
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:57 AM
10/25/2012



Ops Plan FY2012 Apr-Sept [Read-Only] - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Acrobat
K34
=+$K33/$J33*$J34
August 2012
Reporting Day
31
Sinter
Furnace
Refinery
For Month
8/1/2012
# of Days
Date of Revision
Revision #
Header
August 2012
Page 1
Apr
May
June
July
Aug
Sept
Ready
60%
10:57 AM
10/25/2012